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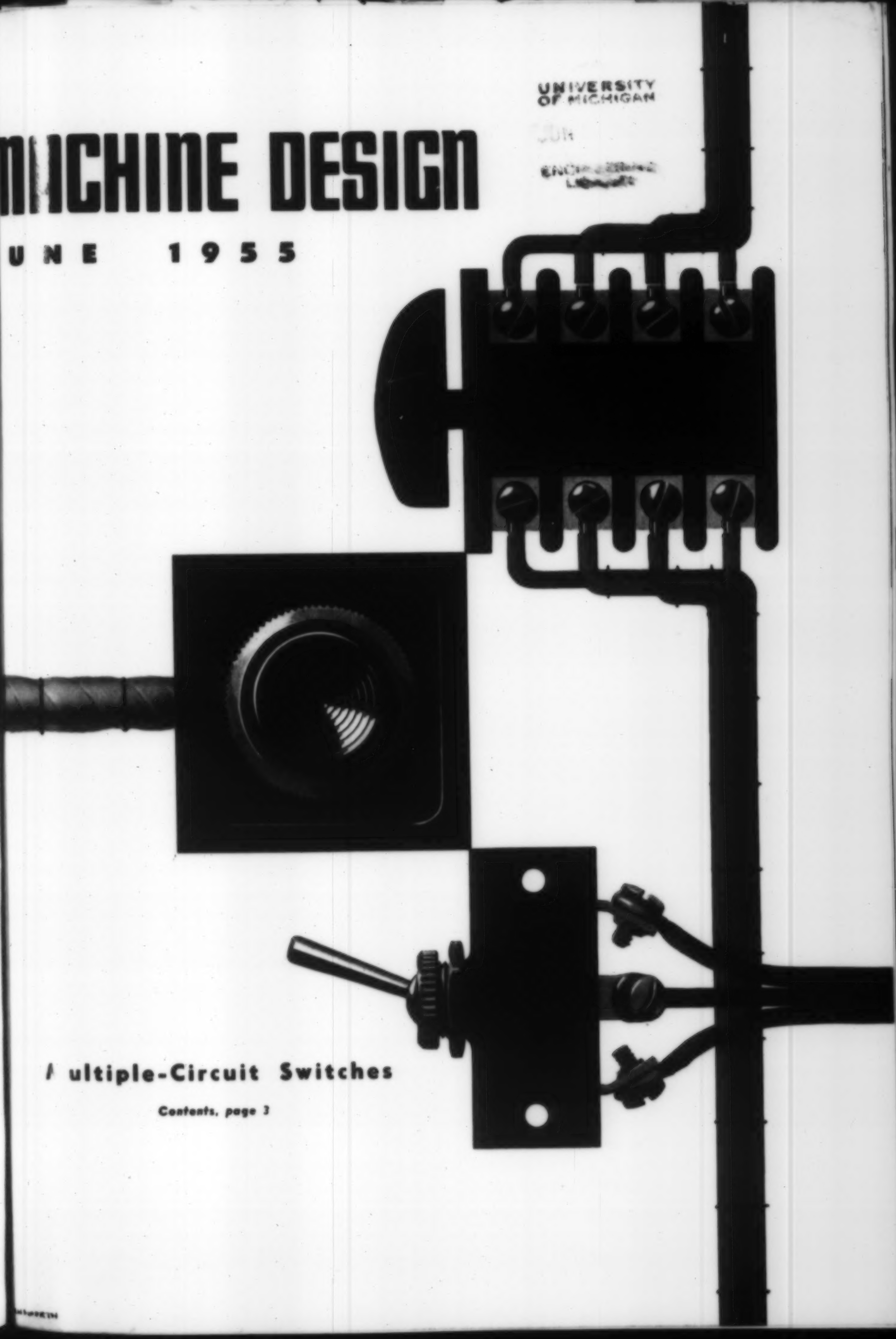
MACHINE DESIGN

UNE 1955



Multiple-Circuit Switches

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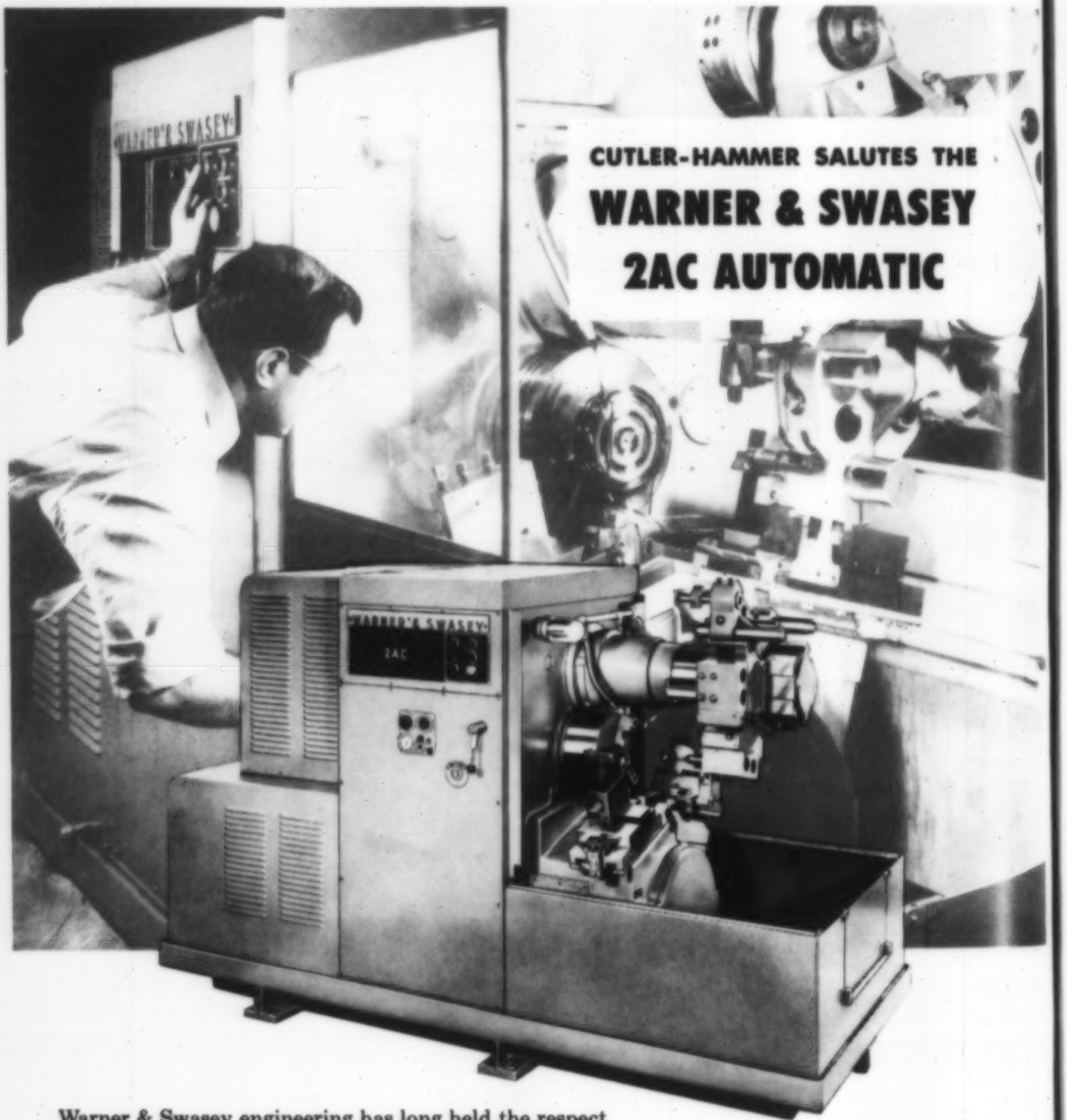

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WARNER & SWASEY
2AC AUTOMATIC

Warner & Swasey engineering has long held the respect and admiration of machine tool users. This was forcibly demonstrated again when 88 shops ordered the new Warner & Swasey 2AC Automatic Chucking Machine before even the *first* one was ever built. Cutler-Hammer is proud to salute a company that can win and justify such confidence by performance. Nothing else can do it. We are also proud that Cutler-Hammer Motor Control plays a part in this performance. Hundreds of Warner & Swasey 2AC Automatics in use all over the country today commend the engineering judgment that equipped them with Cutler-Hammer Motor Control. CUTLER-HAMMER, Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ont.

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OF BETTER MACHINES

THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

JUNE 1955
Vol. 27—No. 6

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Over the Board

Two Promotions Announced

Our sharper-eyed readers will notice that two new titles grace the editorial masthead on Page 3. Keith Carlson and Bob Rodgers have both been promoted from assistant to associate editors. Readers are probably most familiar with Keith as the author of two series of articles on "Multiple-Circuit Switches" and "Internal Combustion Engines." Keith also handles our "Contemporary Design" features. Bob Rodgers will be remembered for his 64-page *opus magnus* on "Adjustable - Speed Electric-Motor Drives" last October, and Bob also has charge of our "Data Sheet" and "Scanning the Field for Ideas" departments. Both have done an outstanding job, and the promotions are well deserved. If you'd like to meet Keith and Bob face to face, their pictures are on Page 50.

Unexpected Recognition

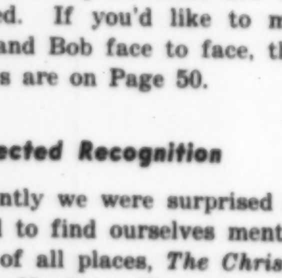
Recently we were surprised and pleased to find ourselves mentioned in, of all places, *The Christian Science Monitor*. The column was by Mary von Soden and read in part: "We have a small experimental laboratory attached to our home and sometimes my husband, who is a mechanical engineer specializing in the field of electronics, lets me come in and look around if I keep still and don't ask him questions while he is busy . . . The other day I took a casual look at the books and magazines stacked on shelves and read the titles of a few: MACHINE DESIGN, *Precision Spindles, Industrial News, Gazette of the United States Patent Office, Fundamentals of Industrial Electronic Circuits, Handbook of Chemistry and Physics.* There were rows upon rows of them." No question which publication must have occupied the position of honor.

MD Wins Again!

Again this year—and with a great deal of pride—we have an award announcement to make. MACHINE DESIGN has won two editorial awards in the annual editorial awards competition conducted by *Industrial Marketing* magazine. One award—a bronze plaque for first place—was for our May, 1954 special issue on engineering materials, the best single issue published by an industrial publication during 1954. The other—a certificate for second place—was awarded for Bob Rodgers' article on "Adjustable-Speed Electric-Motor Drives" (October, 1954) in the competition for best single article. For more details see the story on Page 14.

This Month's Cover

Three types of manually-operated multiple-circuit switches are combined in George Farnsworth's striking design on this month's front cover. All three types—rotary, push-pull and lever-operated—have been discussed in a series of articles by Keith Carlson in previous issues. This month, Keith has summarized the subject in an article on "Selection Factors," Page 149.



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BPA NBP

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These parts cost $5^{02} to manufacture and assemble...

This Stemco thermostat costs only 46¢ and does the job better...

The parts shown above were used to control temperature in a waffle iron. According to the manufacturer, the 31 manufacturing and 4 plating operations cost approximately $2.37 per set plus $2.65 for assembly and calibration.

So he brought his problem to Stevens. Our engineers analyzed his product, proposed using the trim, compact Stemco Type S thermostat—which costs only 46¢ and mounts with a single rivet.

Result? Thermostatic control costs were slashed almost 90% and the waffle iron now works better than ever.

If thermostatic control costs are your problem, chances are we have the answer. Why not give us a try now.

STEVENS manufacturing company, inc.
Lexington and Mansfield, Ohio

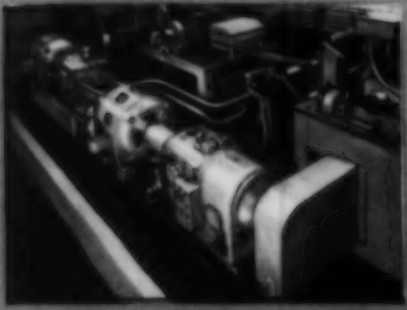
STEMCO® THERMOSTATS

Stevens makes thermostats used in leading makes of
Roasters • Fry Kettles • Vaporizers • Flat Irons • Butter Warmers
Refrigerators • Water Tanks • Waffle Irons • Percolators • Steam Irons
Sterilizers • Rectifier Fans • Electronic and Avionic Devices

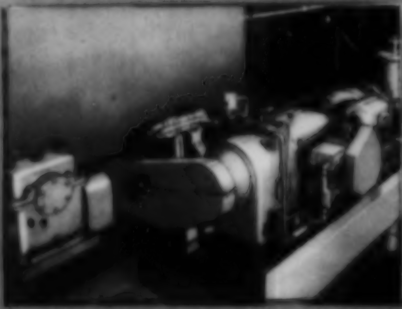
OILGEAR FLUID POWER DRIVES

"Stalpeth" machines add moisture barriers to telephone cable

These machines receive cable core, wrap it in aluminum and steel, solder the seam and coil it on reels. Oilgear *ANY-SPEED* Fluid Power Drives are an easy and economical means of synchronizing many machine units without a long lineshaft.



These Oilgear *ANY-SPEED* units drive the aluminum and steel corrugator units in perfect unison with the governing capstan unit.



The Oilgear *ANY-SPEED* capstan drive. Not shown here is another Oilgear unit driving the cable winding reels.

Solving the problem f close synchronization of driven members

machines become more and more mplex, combining more and more nctions into a single unit, the oblem of driving these machines ccessfully becomes more difficult.

This problem confronted Western ectric Company engineers in degning what they call their "Stalth" machines, two of which are own above. These machines comne corrugating of steel and alumim strips, forming them around the ble core, soldering the seam and en winding the assembly on reels the far end. All of the members of e machine must be synchronized the speed of the capstan unit. oing by their experience with her somewhat similar machines, estern Electric engineers again rned to Oilgear *"Any-Speed"* Fluid Power Drives, to solve what is really a complex problem ordinarily. Oilgear units provided an easy and economical means of synchronizing many machine components.

Oilgear *Any-Speed* Fluid Power Drives and transmissions *do* offer many machine design advantages including ease of control and synchronization of driven members, steplessly variable speed, fundamentally simple circuits, and long, trouble-free life. Write for Oilgear drive bulletins. THE OILGEAR COMPANY, 1568 W. Pierce St., Milwaukee 4, Wisconsin.

OILGEAR
Fluid Power

PIONEERS . . . NOW THREE PLANTS
FOR FLUID POWER
PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS AND VALVES

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Answering the need for VERSATILITY in electric motors!

NEW DEPARTURE BALL BEARING
FACTS
NUMBER 4

End applications for modern electric motors are extremely varied. They may be mounted in positions from horizontal to vertical. Radial and thrust loads may be encountered in numerous combinations. Mounting locations may make periodic lubrication difficult or costly. Atmospheres may be charged with abrasive dust, or extreme cleanliness may be mandatory, with no lubricant leakage allowable.

All these conditions are directly related to the motor bearings—in fact *the versatility of a motor, or its ability to meet them, depends on the bearings used.*

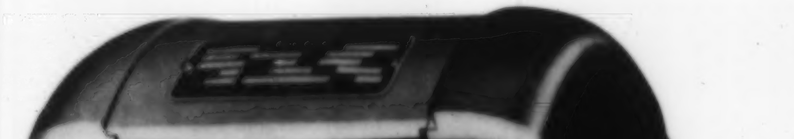
BALL BEARINGS ARE THE ANSWER

Among the important features of the ball bearing are its ability to resist loads imposed from any direction and to locate rotating parts accurately and positively for many years of service. In electric motors accurate rotor-to-stator relationship is maintained regardless of mounting position, and bearings are cool-running at all speeds.

Lubrication factors are important too. Motors equipped with New Departure self-sealed or shielded bearings may be installed in difficult-to-reach places because the bearings will operate for years under normal conditions without attention for lubrication or adjustments of any kind.

With New Departure self-sealed, grease-lubricated ball bearings, lubricant leakage is no problem and the bearings are fully protected from abrasive dirt.

Just as New Departure has pioneered bearing developments which have added so greatly to the versatility of today's electric motors, so will New Departure be first with the bearing advances of tomorrow. New Departure, Division of General Motors Corporation, Bristol, Connecticut.



This Delco general-purpose, drip-proof motor is equipped with New Departure self-enclosed ball bearings. They not only assure permanently accurate support of the rotor shaft under all load conditions, but in normal operation they reduce bearing lubricating requirements to just about zero. However, should extra-severe conditions warrant it, the lubricant can be replenished quickly by removing the pipe plugs.

Note that the bearings have built-in seals on the inside faces, thereby preventing grease leakage into the motor, and the outer faces have metal shields which keep foreign matter out of the bearings. The shields do, however, permit entry of just the right amount of grease from the space in the end bell for perfect bearing operation, yet prevent excessive lubrication which could cause overheating.

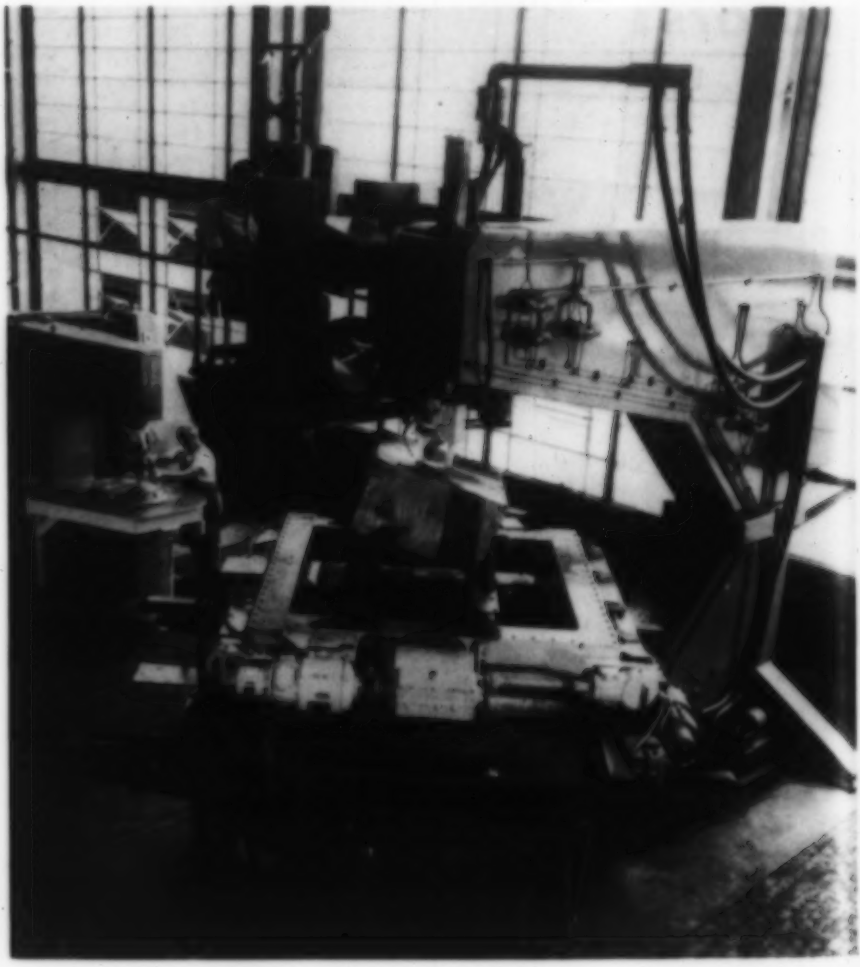
NEW DEPARTURE
BALL BEARINGS
NOTHING ROLLS LIKE A BALL

Engineering News Roundup

Work "Steered" Into Giant Bandsaw

Work is "steered" along a designated path into a new giant bandsaw. A "steering wheel" control associated with an electronic device automatically co-ordinates the movements of three power-driven tables. The work is guided automatically by an operator who sits in a control station suspended from the head of the machine. Height of the station can be electrically adjusted over a 28-inch range, and the station can be rotated manually through 90 degrees. Closeup of the cutting action is obtained through a viewer employing a periscope-like arrangement of mirrors.

An indicating control system using strain gages informs the operator of the pressure between the work and the saw band, and the system will maintain the pressure value set by the operator. Automatic safety checks stop all table feed motors if cutting and feed forces become excessive. On the control panel are hydraulically actuated controls for adjusting and maintaining band tension, assuring upper saw guide position, shifting saw speed ranges, varying speed within a range, and tilting the three saw-band carrier wheels to "track" the saw band. Chips are removed from the layout line at the top of the workpiece by an air jet. A recirculating coolant system permits finer finish and longer saw life by lubricating and cooling the saw band and workpiece.



Over-all view of the DoALL remote control band saw. Almost 16 feet high and weighing 8 tons, it can handle pieces up to 26 inches thick by 52 inches in diameter, weighing up to 10 tons. Saw blades 40 feet long are required for the machine

The machine incorporates a band speed range of 50 to 2000 fpm. It accepts saw bands from 1½ inches to 3/32-inch in width, thus permitting a high degree of maneuverability. Extremely sharp radii, ranging from 1/16-inch, can be cut.

Built by the DoALL Company

Joe Vuille says it's simple arithmetic:
"180 cups per min. x 60 min. x 40 hours per week x 5 weeks=

2,160,000 brass cups in one uninterrupted run"

From the cup illustrated actual size above, socket shells are produced in eight operations on special equipment, followed by a stress-relief anneal and a final bright-dip.

Socket shell caps like this are formed in an 8-operation multiple-plunger press at the rate of 86 per minute.

Typical of Leviton's complete line of lampholders is this "Electrolier Push Thru" model. Both shell and cap are made of ANACONDA Brass.

For more than 20 years, Joe has been pressroom foreman of Leviton Manufacturing Company, Brooklyn, N. Y., one of the world's largest manufacturers of electrical wiring devices.

Multi-million production runs of stamped and drawn products are nothing new to Joe, but he'll admit that there's more to it than a multiplication table:

"First," says Joe, "you start with a good product design. Then the toolroom calls on its broad experience in diemaking. Next, good equipment and good housekeeping are essential in the pressroom. And then there's the brass: these extra-large coils of brass strip have to be just so . . . in dimension, composition, grain size, temper and surface finish . . . lot after lot after lot . . . tailor-made for the job."

Each year Leviton uses many thousands of pounds of ANACONDA Brass, produced to Leviton's precise specifications, "just so . . . lot after lot after lot . . . tailor-made for the job." Perhaps we can perform a similar service for you? Write to *The American Brass Company, General Offices, Waterbury 20, Connecticut*. In Canada: *Anaconda American Brass Ltd., New Toronto, Ontario.* 5579

You can always depend on

ANACONDA®

copper, brass and bronze

for Alcoa, the bandsaw is said to be the world's largest. Its development was said necessitated by demands for rapid machining of dies too large and heavy to be manipulated directly by hand. The saw is being used to fabricate large aircraft members in one piece, thereby eliminating riveting of small assemblies. Using the contour sawing method, the unwanted portions of the block are removed in whole sections. Savings are claimed possible since these pieces can be salvaged for other purposes.

Control station showing steering apparatus, control panel and mirror closeup of work surface

Announce Successful Titanium Shear Bolts

Shear bolts made of titanium that show comparable strength to steel shear bolts have recently been developed. Made by Standard Pressed Steel Co., the new titanium bolts are expected to substitute directly for steel shear bolts in aircraft applications. It is estimated that 95 per cent of total bolt weight in aircraft consists of shear bolts.

Titanium shear bolts weigh about 57 per cent as much as the equivalent steel shear bolts. With their use, as much as 500 to 1000 lb may be cut from the weight of an average aircraft, according to the company.

Tests conducted by company engineers indicate the ¼-inch diameter titanium bolts withstand a load of 60,000 psi when stressed for 8 million load cycles. Fatigue tests of a ½-inch titanium bolt show an endurance strength of 30,000 psi.

Shear tests have resulted in a shear strength figure of 109,200 psi for the ¼-inch bolt. The ½-inch bolt has a shear strength of 112,000 psi. On a weight basis, tests show that titanium bolts have a shear strength about 60 per cent greater than that of steel bolts.

Techniques developed during work on Standard Pressed Steel's tension bolt (See MACHINE DESIGN, April, 1955, Page 18) have been applied to the development of this new shear bolt. These techniques include surface finishing to 8 microinches or less, closely controlled hot forging and a new method of rolling fatigue-resistant threads.

New titanium shear bolts are said to be available in sizes from No. 10 through ½-inch diameter.

Engineer Hiring Sets New Records

Virtually every record for recruiting engineers at Columbia School of Engineering has been broken this year, according to Miss Mary A. Wegener, acting director of the Columbia Placement Bureau. Records broken are:

1. Starting salaries in all degree categories.
2. Number of companies competing for available men.
3. Companies hiring two and three years ahead.
4. Offering jobs earlier in the semester.

Starting salaries of about $400 per month are being offered, compared to $375 in 1954 and $275 in 1949. Electrical engineers and electronics men are the most demanded, with the next greatest demand for chemical and mechanical engineers, and a growing demand for industrial engineers.

Aircraft companies are recruiting the most men, with electronics and chemical industries next.

New research laboratories are being built near Cleveland by Union Carbide and Carbon Corp., to be managed by National Carbon Co. Activities will be directed toward discovery of new and fundamental material-process applications. Among possible future developments are materials for new and improved transistors and related electronic devices, and development of new "ferrites" which could have wide application in electronic com-

MACHINE DESIGN Wins Two Awards

As announced last month, MACHINE DESIGN was the recipient of two national awards in the 17th Annual Business Paper Editorial Achievement Competition.

MD received a first-award bronze plaque for the best single issue in the industrial group. According to the judges, the best single issue was the engineering materials special issue of May, 1954.

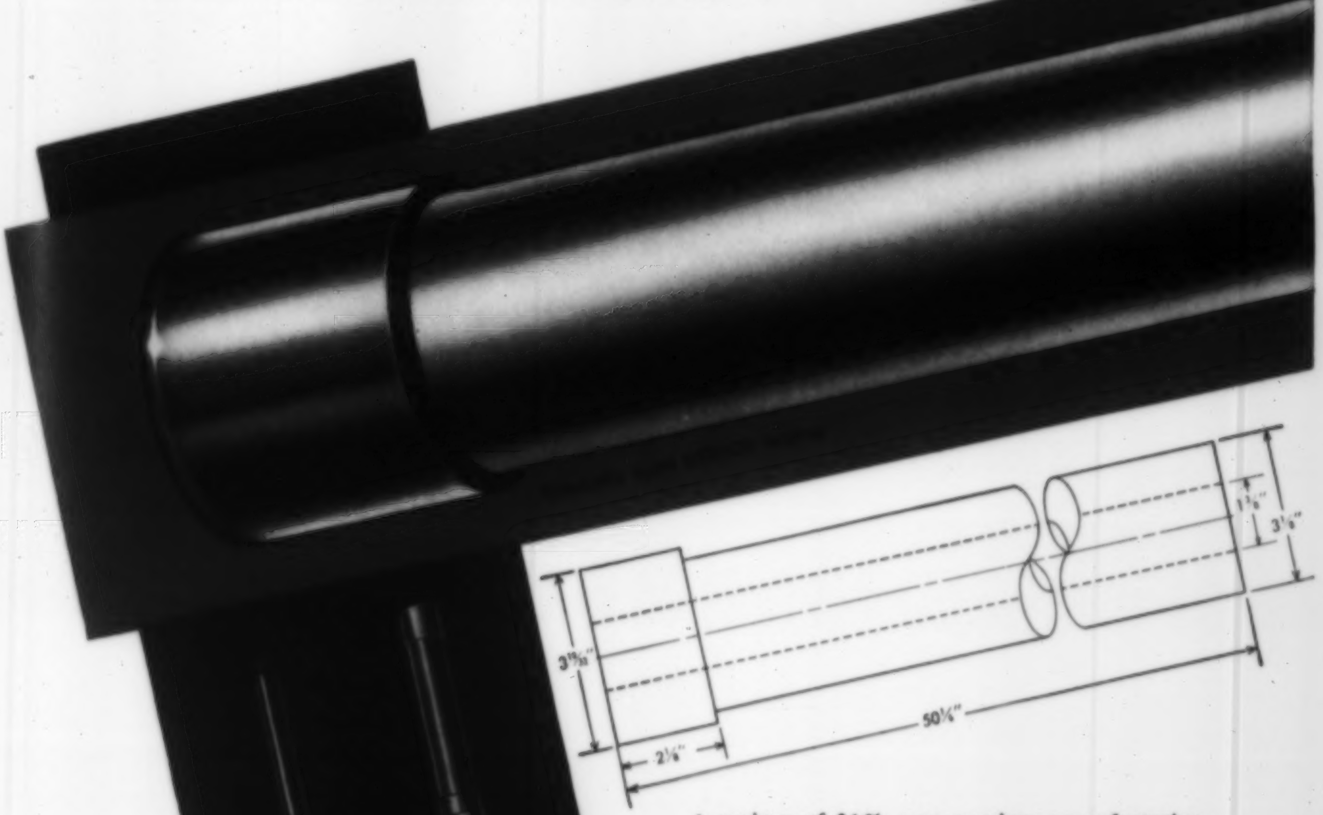
The article, "Adjustable Speed Electric-Motor Drives," took a second-place certificate for the best single article. This 64-page epic by Bob Rodgers appeared in MACHINE DESIGN for October.

Winners were chosen from a field of 475 entries by 25 judges. To date, MACHINE DESIGN has won more awards, 19, in this competition than any other engineering or design publication.

Externally Upset OSTUCO Tubing

saves 31% on processing improves mandrel life

for Halliburton Oil Well Cementing Company



Machined Mandrel
Complete Expanding Shoe Assembly

A savings of 31% over previous manufacturing methods, was made possible by using externally upset OSTUCO Tubing as Wall Packer Mandrels in "Howco" Expanding Shoe Assemblies. These OSTUCO forgings eliminated a welding operation and reduced machining time and cost. One-piece fabrication greatly improved the useful life of the part.

Compare your tubing costs with job-designed OSTUCO Tubing. *Special-quality* OSTUCO Tubing is manufactured to your individual requirements . . . formed to save processing time and waste. Fill all your tubing requirements on *one* order with OSTUCO'S unique *single-source* service. You'll eliminate interplant shipment, reduce error and speed delivery. Wire, write or phone OSTUCO for complete details, or submit blueprints for immediate quotation.

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puters and automation devices. Developments also may include new refractory compounds, as well as improvements in established materials, such as graphite; and photosensitive materials leading to new and more efficient methods of converting light energy to electrical energy.

Most Nickel Used for Stainless Steel

A recent report by the International Nickel Co. disclosed that the principal use of nickel throughout the world in 1954 was in the production of nickel alloy steels.

Based on data issued by the United States Bureau of Mines, the greatest percentage of nickel was used in the category which includes stainless steels. This category accounted for 36 per cent of the total consumption.

Production of malleable nickel and nonferrous alloys, including copper-base alloys, nickel silvers and high-nickel alloys used 30 per cent of the total. Electroplating accounted for 16 per cent.

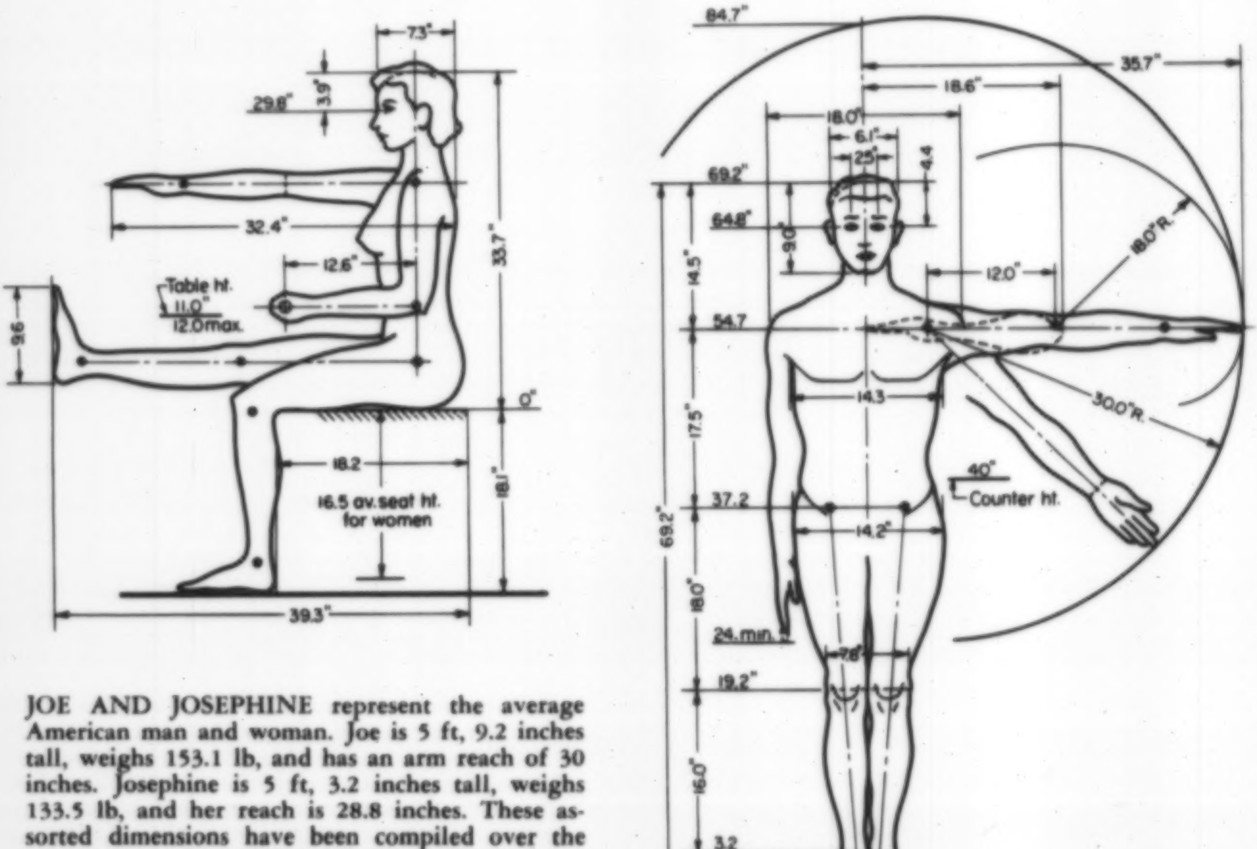
High-temperature and electrical-resistance alloys took 7 per cent. Cast iron production took 4 per cent, catalysts 1 per cent, and magnetic alloys 1 per cent. Miscellaneous applications accounted for the remaining 5 per cent.

Aerosoloscope Measures Airborne Particles

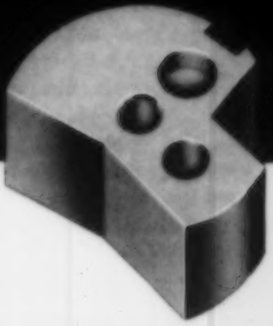
An electronic instrument, capable of measuring and counting airborne particles at the rate of 100 per second—1000 times faster than by conventional methods has been developed by Armour Research Foundation for the Army Chemical Corps.

The instrument, called the aerosoloscope, can be used to count and measure airborne particles ranging in size from 1 to 64 microns in diameter. It employs as its basic principle of operation the interaction between very small particles of matter and light known as scattering.

Since large particles scatter more light than small ones, a photomultiplier tube, in connection with other electronic apparatus, can determine the size of each particle. Electrical impulses are created by the photomultiplier tube when it detects the scattered light. These impulses are transmitted to a set of 12 dials. The first dial records the number of particles 1 to 1.4 microns in diameter. Each succeeding dial records slightly larger particles than the preceding one.



JOE AND JOSEPHINE represent the average American man and woman. Joe is 5 ft, 9.2 inches tall, weighs 153.1 lb, and has an arm reach of 30 inches. Josephine is 5 ft, 3.2 inches tall, weighs 133.5 lb, and her reach is 28.8 inches. These assorted dimensions have been compiled over the past 25 years by industrial designer Henry Dreyfuss and his staff for use in designing machines that fit people



From the collection of Lewis Winant, New Jersey Arms Collectors Club. Maker: Wogdon, London, 1786-1787. An 11-by-14 inch print of this illustration will be sent free when requested on company letterhead.

challenge accepted

When this booster rotor, an artillery fuse component, was offered for production to the powder-metallurgy industry, Bound Brook was among those who were quick to accept the challenge. Initially, the part had been produced by machining brass bar stock, a method which proved to be both excessively costly and discouragingly slow. Powder metallurgy fabrication looked simple enough at first, until the critical weight and dimension factors were examined more closely—for in artillery fusing the difference between a hit and a dud can depend on a thousandth of an inch. By mustering all of its know how, accumulated in more than 30 years of producing metal-powder parts, Bound Brook emerged as the major producer of this rotor—at a cost nearly 40% less than was required for conventional machining.

10

BOUND BROOK

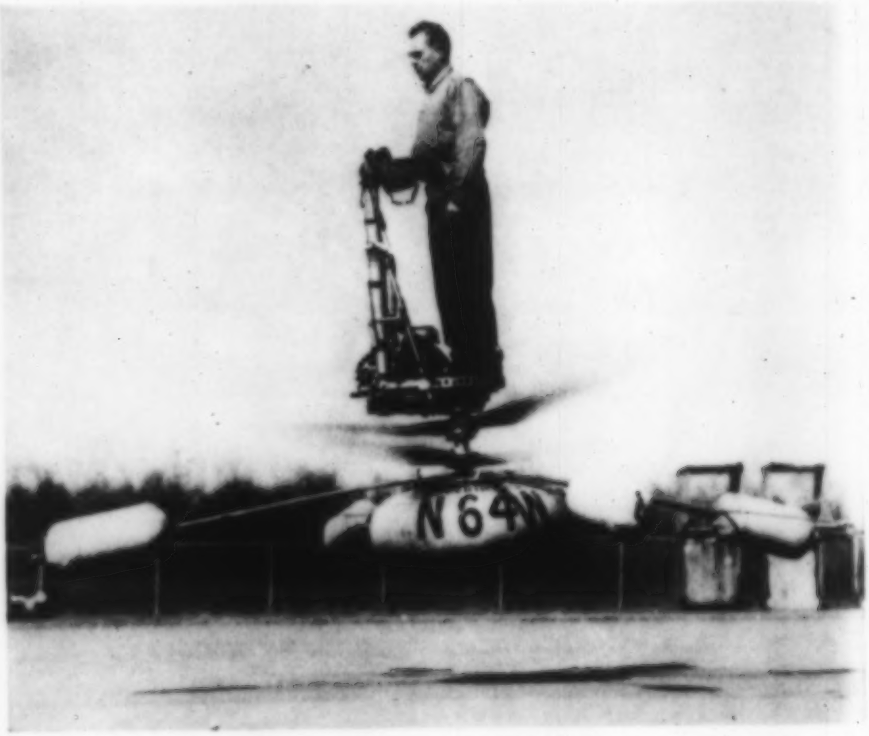
BOUND BROOK OIL-LESS BEARING CO., EST. 1883, BOUND BROOK, N. J.

Pioneer in

POWDER METALLURGY BEARINGS + PARTS

Pilot "Leans" to Steer New Helicopters

Two models of one-man helicopters have recently been developed. Controlled by shifting the weight of the pilot, these aircraft eliminate conventional controls and instruments. Directional flight is achieved by leaning in the desired direction. Although developed primarily for the armed forces, extensive civilian use is possible because of simplification of controls.



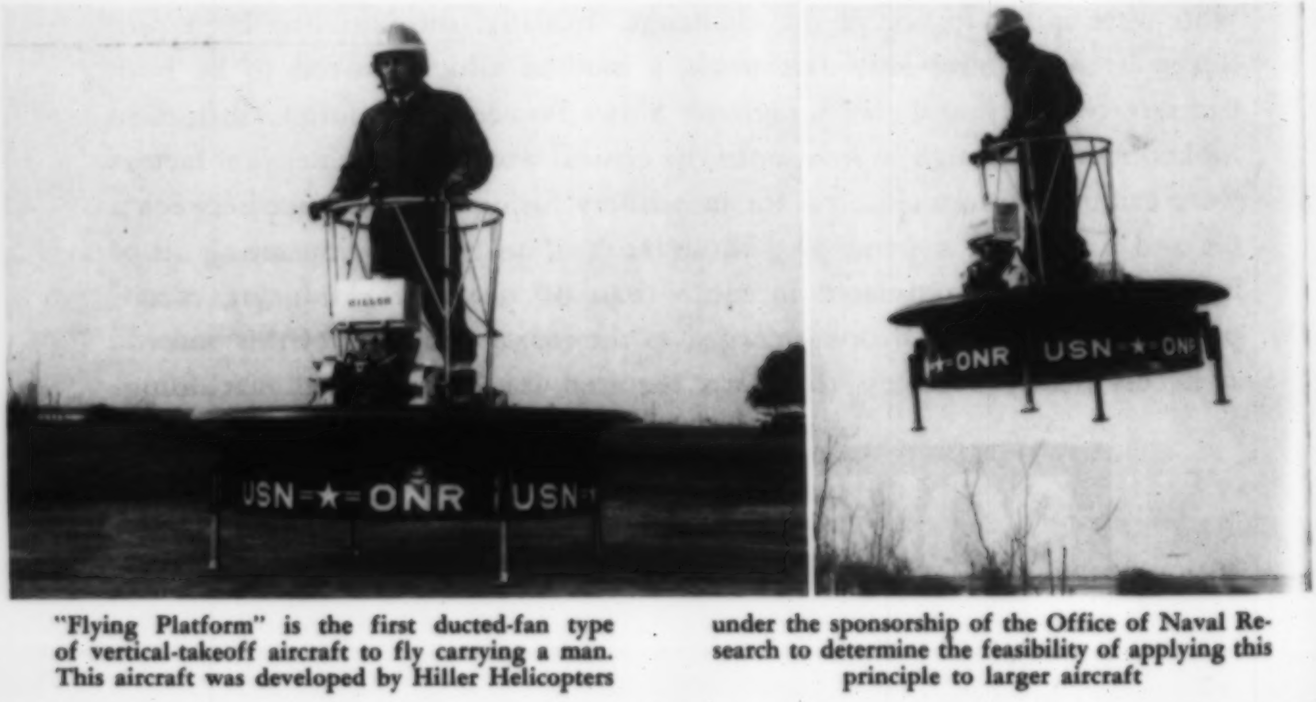
With its two 15-ft blades counter-rotating, the DH-4 Heli-Vector is shown in test flight. This one man amphibious helicopter introduces the "stand on" or "vector" system of flight control

DH-4 Heli-Vector

One version of this new type aircraft, the DH-4 Heli-Vector, incorporates these new basic principles of guidance by weight shifting. This system has a greatly simplified structure, eliminating the need for cyclic pitch controls and reducing pilot training time. The machine was developed by de Lackner Helicopters Inc.

The Heli-Vector is powered by a four cylinder, two-cycle Mercury outboard engine, liquid cooled, developing 43 hp at 6000 rpm. The engine is mounted above a large center under-float and four smaller extended floats. Power transmission is by dual V-belts with a stable, automatic torque balancing unit and autorotation cam clutch combined with a primary chain reduction unit.

Two 15-foot diameter rotors are counter-rotating. No flight controls are required except throttle and yaw control which are provided by a twist grip throttle and typical motorcycle handlebar steering. Roll and pitch are accomplished by the pilot leaning in the direction of the motion desired.



"Flying Platform" is the first ducted-fan type of vertical-takeoff aircraft to fly carrying a man. This aircraft was developed by Hiller Helicopters under the sponsorship of the Office of Naval Research to determine the feasibility of applying this principle to larger aircraft

ARE YOU TAKING ADVANTAGE OF THE BIG 'MOTOR SWITCHOVER?'

Brand-new standards for 1 to 30-hp motors, proposed by motor manufacturers (NEMA) in 1953, have already been accepted by more than 75% of American industry.

The major factor behind this rapid switchover is that motor buyers are now taking advantage of the longer life, lower maintenance, and better performance afforded by the new motors. Machine performance can be improved with the new G-E Tri-Clad* '55' motor, because of its higher full-load operating speeds.

Users are also getting longer life out of the new G-E motors, because of the new insulation which is 8 times stronger than ordinary motor insulation. Maintenance has been greatly reduced through the use of a new synthesized grease with 4 times greater lasting power, and perma-numbered leads which can be identified even when taped or clipped.

Are you investing in motor progress or motor obsolescence? You can take advantage of all these latest improvements if you specify G.E.'s new Tri-Clad '55' motor. Contact your G-E Apparatus Sales Office or authorized G-E motor supplier today. *General Electric Co., Schenectady 5, New York.* 648-28

*Reg. trademark, General Electric Co.

"BEST PERFORMING MOTOR that G.E. ever built," says W. J. Conery, chief design engineer of F. E. Myers & Bro. Co., Ashland, Ohio, about the new G-E Tri-Clad '55' motor. Higher full-load speed, smaller size and weight, and modern appearance permitted Myers to reduce size and improve performance of their Centri-thrift (left) and Ejecto (right) pumps.

"FAR EASIER TO OPERATE because of the new motor frame sizes," reports Stephen Bader & Company, Valley Falls, N. Y., in behalf of their new "Space-Saver" polishing machine. The 22% weight reduction in the 2-hp G-E Tri-Clad '55' motor allowed the machine to be redesigned for easier "one-man" handling. Higher full-load speeds permitted improved performance.

Progress Is Our Most Important Product

GENERAL ELECTRIC

(Continued from Page 21)

minations on requests for delay of recall of reservists to active duty. Local draft boards of the Selective Service System also have the lists available for consideration in making decisions on requests for occupational deferments.

New Tester Checks Hardness, Lubricity

Dynamic hardness and natural lubricity of a material has been found to be a function of its resistance to being marked or scratched. This principle is the basis of a new test device called the Dyhedron.

Made by Taber Instrument Corp., the Dyhedron uses an octahedral-shaped diamond that penetrates the material. As the diamond oscillates at a constant rate, it works its way into the material. Depth of penetration is indicated by a dial micrometer. When a predetermined standard depth is reached, the number of oscillations is read from the counter. This latter figure is said to be the basis of comparison between specimens. In the case of bonded granular materials, the lower the counter reading, the weaker, more friable the bonded structure. Previously approved materials are suggested as the basis of the standards.

According to the company, the new tester does not obsolete the brinell, Rockwell or Knoop hardness tests, but complements their results. Its applications are said to range from soft plastics to steel. Both solids and granular materials may be tested.

Failure of machine parts will be discussed in a one-week course this summer at the College of Engineering of the University of Michigan. Further information may be obtained from Rune Evaldson, Department of Mechanical and Industrial Engineering, University of Michigan, Ann Arbor.

The Cemented Carbide Producers Association has been formed by manufacturers of cemented carbides containing tungsten, for the

World's Largest Tractor Has Turbocharged Engine

After ten years of research, Caterpillar Tractor Co. has come up with what they claim is the world's biggest, most powerful production crawler tractor. This Cat D9 develops 230 drawbar horsepower using a turbocharged $6\frac{1}{4}$ by 8, six-cylinder diesel engine. The engine delivers 286 horsepower at 1200 rpm for both a torque-converter and a direct-drive model. A two-cylinder starting engine has a 6-volt electric starter. Oil lines, fuel lines and water tubes are placed internally as much as possible.

World's largest production tractor, according to Caterpillar Tractor Co., is powered with a turbocharged diesel engine

Features of the engine include: (1) short valve push rods, (2) stationary oil jets to provide a continuous stream of oil to cool the pistons, camshaft and followers, and (3) steel-backed aluminum bearings with the lower half of the center main bearing taking the camshaft thrust on a flange.

The torque converter is a three-stage, 5:1 torque-multiplication unit using diesel fuel for the hydraulic fluid. A 19-inch single-plate, dry type flywheel clutch is used with the torque converter. Torque-converter fluid cooling is provided by a water type heat exchanger mounted on the right side of the engine. Speeds up to 7.8 mph with three speeds forward and two in reverse are provided. The direct drive has six speeds forward and six in reverse ranging from 1.6 to 6.8 mph. With the direct drive transmission, drawbar pulls of 60,860 pounds are possible.

With conventional drive, the tractor weighs 56,200 lb; the torque-converter model weighs 56,650 lb.

Specify

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Result:

Economy

"Economy . . . counts not in savings but in selection."—*Edmund Burke*

Economy through Efficiency

Gits Unit Seal proves itself in dependable performance over a wide range of operating conditions—including extra-high speed, heat and pressure applications. Operation at peak efficiency always means dollars-and-cents savings.

Economy through Adaptability and Versatility

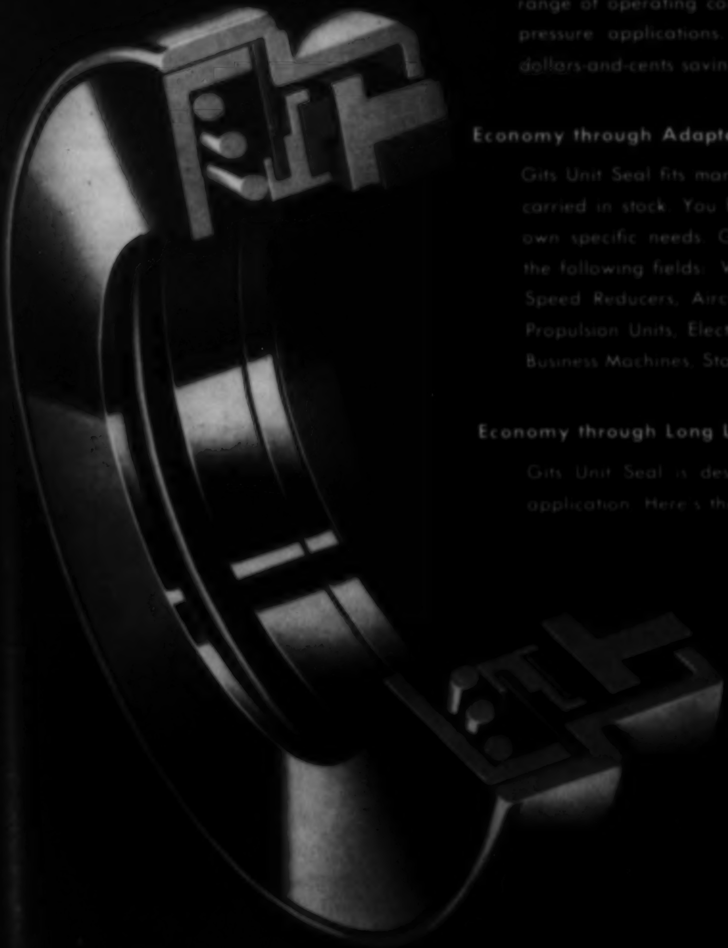
Gits Unit Seal fits many applications as a standardized item actually carried in stock. You harness the savings of mass production to your own specific needs. Gits Unit Seal already has wide application in the following fields: Washing Machines, Disposal Units, Gear Motors, Speed Reducers, Aircraft Turbine Pumps, Accessory Drive Units, Jet Propulsion Units, Electrical Power Equipment, Automotive Accessories, Business Machines, Standard and Special Machine Tools.

Economy through Long Life

Gits Unit Seal is designed for maximum life in any recommended application. Here's the real "proof of the pudding" in saving money.

Write Today For FREE Illustrated Brochure or send us your seal problem. Our experienced engineering staff is at your service.

*Cartridge Seal requiring only 25% more space than lip-type seals.



GITS BROS. MFG. CO.

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VIBRATION-DAMPING
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SKID-PROOFING
CUSHIONING
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SCRATCH-PREVENTION
GLAZING STRIP
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RESILIENT CORK-AND-RUBBER
TACKY ADHESIVE

SKID-PROOFING

Give office equipment an economical, non-slip base with Armstrong DK-153 Tape. This cork-and-sponged-rubber material grips firmly, even on polished surfaces . . . makes equipment easier to use. And because it's resilient and non-marking, DK-153 also protects desk and table tops . . . eliminates the use of separate pads or cushions.

Armstrong DK-153 Tape is coated on one side with a pressure-sensitive adhesive that sticks to nearly any clean, dry surface. Just peel off the cloth backing and press tape into place.

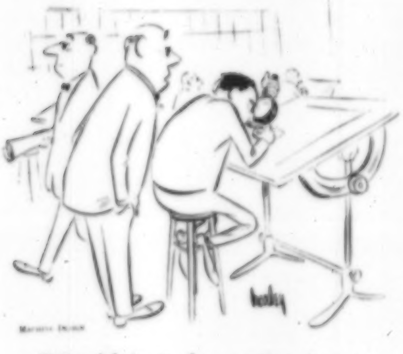
DK-153 is available in tapes, sheets, rolls, or die-cut shapes and in a variety of thicknesses. For samples, write on your letterhead to Armstrong Cork Company, Industrial Division, 7306 Dean St., Lancaster, Pennsylvania. Available for export.

Armstrong DK-153 TAPE

purpose of furthering the use of the products of the industry. Membership is comprised of the majority of producers of the product in the U. S. Affairs of the group will be managed by Hunter-Thomas Associates, Cleveland, O.

Largest aluminum closed-die forging ever made in the United States has been successfully produced by the Bridgeport Brass Co. at its aluminum division in Adrian, Mich. The forgings measure approximately 18 feet long by 4 feet wide and were made on a 16,500-ton press. Such a large forging usually requires a large bed press of 35,000 or 50,000 tons.

The success which has accompanied this program suggests that other similar forgings much larger than normally produced in the 16,500-ton press may be produced, if the design of the part is adaptable to the new forging techniques.



"Wouldn't it be easier to enlarge the scale?"

Tiny Unit Converts Atomic Radiation to Electricity

A tiny semiconductor device that converts either light or atomic radiation directly to usable electrical energy has been developed by Radio Corp. of America. The unit employed in this battery is a silicon junction about ¼-inch in diameter and 0.01-inch thick. The radioactive source employed in the experiments is strontium 90, an atomic fission byproduct.

Using light and radioactive material interchangeably as sources of radiation, these batteries have powered a specially designed low-power transistorized radio receiver.

Batteries capable of such conversion will have application in the future as sources of electricity for low-power electronic equipment, especially in the field of transistorized devices.

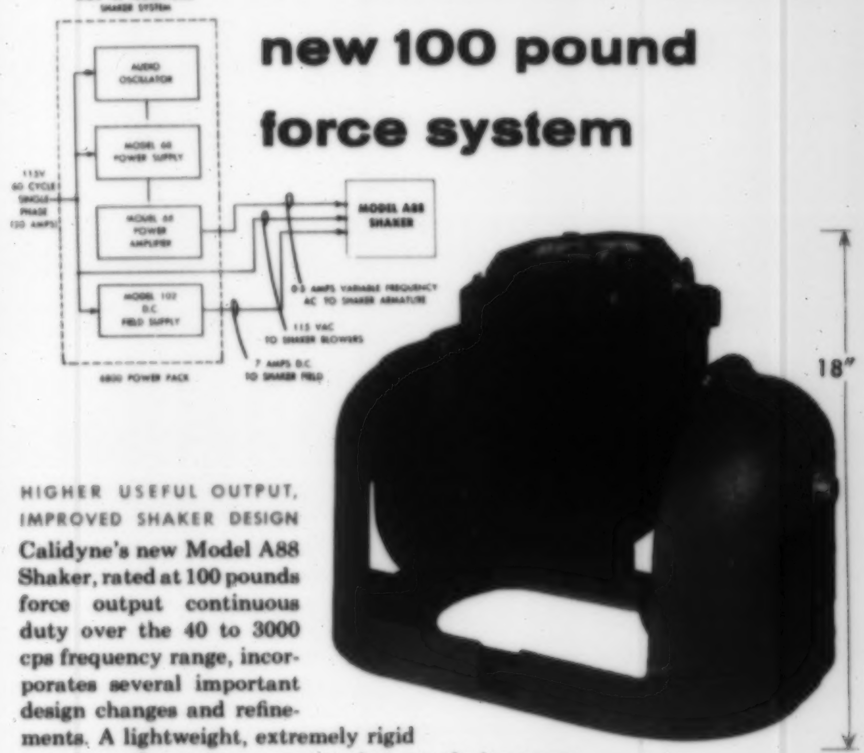
National Society of Professional Engineers will have a new national headquarters building in Washington, D. C. Located at 2029 K Street, the new building will house NSPE executive and administrative offices, and the offices of the *American Engineer,* the Society's monthly magazine. It is expected to be ready for occupancy by January 1, 1956.

First commercially manufactured synthetic mica component—a radio-tube element spacer—has been developed by Synthetic Mica Corp. This spacer is said to improve vacuum-tube reliability since the synthetic material can be made chemically pure and free of the out-gassing components of natural mica at high temperatures. Production of the element spacers requires no specialized machinery; they are punched by conventional manufacturing methods from a sheet of synthetic mica.

Minneapolis-Honeywell Regulator Co. and **Raytheon Manufacturing Co.** have announced a joint undertaking to engineer and market electronic data-processing systems for use in business and government. According to Paul B. Wishart, Honeywell president, and Charles F. Adams Jr., president of Raytheon, the project will be carried out through the formation of a jointly-owned corporation, to be known as **Datamatic Corp.**

American Locomotive Co., Schenectady, N. Y., has changed its name to **Alco Products Inc.** The new name has been adopted to reflect the company's increasingly diversified operations. Locomotive production will still continue to be a major operation.

high performance
SHAKER
in CALIDYNE'S
new 100 pound
force system


BASIC 100 POUND FORCE SHAKER SYSTEM
AUDIO OSCILLATOR
MODEL 60 POWER SUPPLY
115V 60 CYCLE SINGLE PHASE (20 AMPS)
MODEL 69 POWER AMPLIFIER
MODEL A88 SHAKER
MODEL 102 D.C. FIELD SUPPLY
0-3 AMPS VARIABLE FREQUENCY AC TO SHAKER ARMATURE
115 VAC TO SHAKER BLOWERS
7 AMPS D.C. TO SHAKER FIELD
6800 POWER PACK
18"

HIGHER USEFUL OUTPUT,
IMPROVED SHAKER DESIGN

Calidyne's new Model A88 Shaker, rated at 100 pounds force output continuous duty over the 40 to 3000 cps frequency range, incorporates several important design changes and refinements. A lightweight, extremely rigid armature of cage-type construction greatly increases the useful portion of total force output. MIL-E-5272A Procedure I requirements, for example, can be met with mass loads up to 7.3 pounds. Also, a new flexure system insures truly *linear* motion of the armature, and trunnion mounting of the Shaker allows forces to be exerted in any direction. And for monitoring amplitude of vibratory motion, a calibrated velocity signal generator has been built into the Shaker.

SINGLE CONSOLE CONTAINS CONTROLS AND POWER PACK

The 6800 Control and Power Pack unit includes the Power Amplifier, Audio Oscillator, and Shaker Field Supply, as well as all controls and indicators, for operation of the complete system. Accessories for monitoring Shaker vibratory levels and performing automatic cycling tests required in many MIL and JAN specifications may be added to the basic system at any time, by rack mounting in the cabinet.

Complete System Specifications and Details
Available on Request

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As near to you as your telephone

A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Electronics Control Miniature Production Line

Two miniature production lines, electronically controlled, are said to have tripled magnet production. In operation at General Electric's Carboloy Dept., the lines occupy 16 feet of straight-line space. Formerly the same operation required 50 sq ft.

A series of electronically controlled relays actuate conveyors, drop chutes, hoppers, magazine feeders, aligning pushers and other devices for both mechanical inspection and magnetic testing. Two operators handle the entire line.

About 2100 magnets per hour are automatically checked for length, diameter, squareness and parallelism. Length and diameter are said held to a tolerance of 0.001-inch.

Rejected magnets are removed from the line at the point they fail to pass inspection. Solenoid-controlled gates take care of the segregation operations.

Magnetic testing takes place after mechanical testing. Magnetic output is tested in seven energy levels simultaneously using a comparison method. Each magnet is compared to the magnetic energy level of a standard magnet.

Mechanical testing portion of General Electric's electronically controlled magnet production line. Here magnets are automatically checked for length and diameter. If they pass they go on to a magnetic tester

Engine Exhaust Control Slows Down Big Trucks

A new braking system for large trucks has been devised in which the truck engine itself is converted into a low-pressure air compressor to hold back the vehicle.

Placing a specially designed butterfly valve between the manifold and the muffler restricts the exhaust and builds up back-pressure. The resulting braking force achieved is said to be nearly equal to the horsepower output of the engine.

Brake pressure is controlled by a hand-operated valve mounted on the steering post. Pressure is instantly released when the accelerator is depressed.

Advantages of the new system,

You Can Bet Your Bottom Dollar

G.S. GEARS CAN CUT YOUR COSTS!

When rejects reach new lows and your assemblies roll without a hitch, *that's when costs come down.*

UNIFORM accuracy is a specialty here at G.S. It's that "priceless ingredient" in Small Gearing that means so much to the critical customers we serve. It's an achievement realized through 39 years of developing methods and machines to a degree of perfection unapproached in the history of the industry!

Now, with our greatly enlarged facilities, G. S. customers get even better Gearing with greater speed and efficiency than ever! More and more manufacturers from coast-to-coast are turning to G. S. for Small Gearing that improves performance and cuts costs. Chances are we can help you, too. Just tell us what you need. Friendly G. S. engineers will lend you every possible cooperation.

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See where and how we mass-manufacture Small Gearing to uniformly fine tolerances. Folder contains 23 pictures of Small Gears, plant views, as well as Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!

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Consider DUDCO Double Pumps with Valve Panels
from the Standpoint of Their Ability to—
HELP SELL YOUR
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CONTROLLED FLUID POWER TO SPEED UP TRAVERSE AND FEED CYCLE!

DUDCO PF-100 Series Double Pumps with combination relief and unloading valves provide high circuit flexibility through either automatic or external pilot control. For example ... in a "hi-lo" circuit, large volume delivery is available for a fast traverse cycle. Then, during the feed cycle, when small volume is required, one pump section unloads automatically ... saving dollars in horsepower! These pumps can also be operated on separate circuits ... each circuit protected by its own relief valve.

TWO VANES ARE BETTER THAN ONE

The hydraulically counter-balanced DUAL-VANES in DUDCO Hydraulic Pumps eliminate wear producing loads normally caused by unbalanced hydraulic forces and vane acceleration. DUAL-VANES also maintain MULTIPLE SEALING BARRIERS to slippage and power loss. DUAL-VANES are a patented and exclusive DUDCO feature.

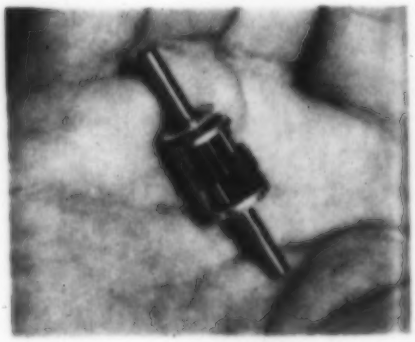
DUDCO Pumps can operate *continuously* at 2000 psi. Their exclusive "Dual-Vane" feature and advanced design combine to assure long, trouble-free performance and maximum simplicity in servicing. Thus, they are a natural choice for a wide variety of high production equipment, including: Machine Tools, Hydraulic Presses, Die Casting and Plastic Moulding Machines, Closing and Clamping Devices and other functions calling for controlled variation in Pump volume.

The PLUS factors in DUDCO Pumps weigh heavily at the sales end—so, WRITE ... get the facts on DUDCO Dual-Vane Hydraulic Pumps and Fluid Motors.

DUDCO DIVISION
THE NEW YORK AIR BRAKE COMPANY
1706 EAST NINE MILE ROAD • HAZEL PARK • MICH.
INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

according to its makers, Power Brake Equipment Co., include reduced wear on brake linings and tires. Shifting to a lower gear going downhill is also said to be unnecessary, resulting in saving time on trips and less driver fatigue.

• • • HYDRAULIC GIRAFFE *is now being used to shake nuts (not human eccentrics) out of trees. A hydraulic system made by Hydreco Div. of New York Air Brake operates the device. A boom equipped with a hydraulically-controlled clamping head is mounted on a tractor. After the boom is raised into the tree and the clamping head attached, an eccentric (mechanical type) operates to shake the tree. According to Gould Bros. Inc., makers of the shaker, the unit can be adapted to shake down apples and other fruit as well.*



SMALL DIFFERENTIAL, believed to be the smallest in existence, has a working diameter of only 17/32-inch. Made by Pitometer Log Corp., the unit uses miniature ball bearings

Thompson Products Inc. has acquired two large manufacturing plants—one in Cleveland and one in Detroit. The Cleveland property was purchased from the White Motor Co. and will be used to relieve pressure for floor space at the Tapco plant in Euclid, O. Construction of a new chassis-parts plant on a 58-acre site in outer Detroit will begin this year.

New Aluminum Alloy Promises Faster Airplanes

Lifting of at least part of the thermal barrier is expected possible with a newly developed experimental aluminum alloy. Called X2219, the alloy is said to have excellent properties at temperatures in the range of 500-600 F. According to Aluminum Co. of America, developers of the new alloy, new aircraft engine applications will be possible as well as high-speed aircraft structural components.

Alloy X2219 is a member of the aluminum-copper group of aluminum alloys containing small additions of several other elements. Typical mechanical properties of X2219 are:

Typical Mechanical Properties At Elevated Temperatures

Temp. at Test (F)	Time at Temp. (hours)	Tensile Strength (psi)	Yield Strength (psi)	Elong. (per cent in 4D)
Room	....	62,000	43,000	16
500	1000	29,000	21,000	24
600	1000	18,000	14,000	26

These elevated temperature results are average values obtained by Alcoa's Research Laboratories. While the data in some cases is limited, values are believed to be representative.

Applications where the new alloy is expected to show promise are in aircraft and automotive engine parts where temperatures reach 600 F. Both gas turbine and piston-type engines have use for aluminum parts operating in that temperature range. Fittings for pressure vessels and pumps are other possible applications.

Solar Aircraft Corp. is building a new research facility in San Diego, which will contain five test cells for testing gas-turbine engines. The entire building will be erected around an 1800-horsepower diesel engine, which weighs almost 20 tons. Special foundations to carry the weight of the diesel engine,

(Continued on Page 36)

Back of the JOHN DEERE No. 55 Combine is a story of . . .

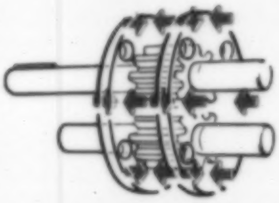
Oil Power

HYDRECO Oil Power

The famous HYDRECO Four-Bolt design Hydraulic Pump provides Oil Power on the John Deere No. 55 Self-Propelled Combine to position the Auger Platform and control the Variable Speed Drive. This model 1506 Pump delivers 3.3 gpm at 1200 rpm with pressures to 1500 psi . . . other models to 130 gpm.

Build the hydraulic circuit around the dependability of HYDRECO components. More and more design engineers find this premise leads to successful performance in service whether the application be farm equipment, machine tools, materials handling or construction machinery.

HYDRECO Oil Power . . . Pumps, Motors, Valves and Cylinders have one important characteristic in common . . . they're *dependable*. And the engineering that contributes this dependability may be relied upon to make significant contributions to your present and projected hydraulic problems.



Pressure Balanced wear plates maintain a fixed clearance between wear plates and gear faces regardless of pressure. This feature in HYDRECO Pumps and Motors minimizes oil slippage and power loss . . . volumetric efficiency and mechanical efficiency remain high!

Write for brochures on HYDRECO Pumps, Motors, Valves and Cylinders.

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TRADE MARK
GEARS

FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Automotive Gear Works, inc.

ESTABLISHED IN 1914

RICHMOND, INDIANA

JUNE 1955

The Easy Way Out

ALL of us believe in engineering and its future, but we are troubled by the general state of affairs which produces cases such as this:

Here's the background of a rather able 33-year old engineer in the west-coast region:

Bachelor degree in mathematics	4 years
Teaching engineering mathematics	2
Bachelor degree in mechanical engineering	2
Engineering in industry	4
Total professional training and development	12 years

Recently this man quit his job. He left a good "solid" company where his activities and salary were pretty much in accordance with average conditions.

Today he's repairing automatic washers and garbage disposal units!

Why has he dumped 11 years overboard and invited the shocked reaction of his professional associates and social circle? To them he has stepped backward, he has acknowledged to them his personal failure as a professional.

But he claims he has not failed; instead, he has succeeded—succeeded in liberating himself from the confines of the white-collar professional. Overlooking his cynicism, what do we find to be his reasons?

He gained an immediate 50 per cent increase in income. He is his own boss—responsible for his own decisions and actions, and immediately aware of their consequences. He experiences personal satisfaction in providing a service for which others depend upon him. He is able to live at the level toward which he had unsuccessfully aspired before.

This man has answered his personal problem. Finding a personal escape route is no answer, however, to the future of engineering and all that depends upon it. But this man's reasons for taking the easy way out give some clues to the right answers: financial income, individual responsibility, personal satisfaction.

Ben Hummel

ASSOCIATE EDITOR

Which part-numbering system?

All numeric?
Mixed numbers and letters?
Serially assigned?
Coded for convenience?

Here's a practical
NUMBER-LETTER SYSTEM

By Charles E. Havener
Administrative Assistant
Harvey-Wells Electronics Inc.
Southbridge, Mass.

IN THE operation of an engineering department, as in most businesses, the maintenance of adequate records is a necessary evil. In business, records are kept to ascertain whether a profit is being made. While this is not the immediate goal of records in an engineering department, proper records are essential to the operation of the remainder of the business and thereby materially affect the statement of profit.

Engineering department records, while consisting of much data, eventually reduce to a list of parts which are to be assembled in accordance with specified instructions, and are to meet certain tests. This list of parts is of primary importance to the operation of the business, since no material can be purchased, fabricated, or assembled without it.

The purpose of this article is to discuss the effect the part and drawing number system has on the rest of the business operation, and to discuss in some detail a combination numerical-alphabetical part numbering system.

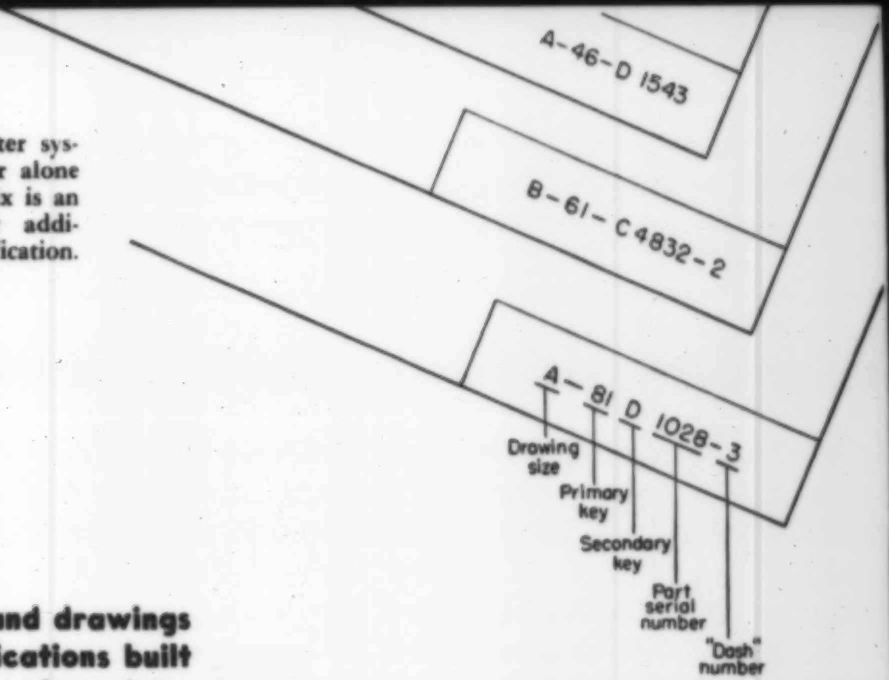
The number assigned to any drawing, in its basic concept, is a record number that will permit filing the drawing so that it may be found at a later date and used as required to make additional prints, or be incorporated into a new design. That the number assigned to the part shown on the drawing be the same as the drawing number (with the possible addition of a "dash" number) is simple logic, provided the various departments who handle the actual material can do so under that number. To assign another number to the part merely to make handling possible is duplication of effort, and therefore the original number must be of a form that can be used to best advantage throughout the entire business.

Straight serial numbering is the simplest of all methods of assigning numbers. In this method a record book or a set of cards is prenumbered in straight numerical sequence. As soon as a number is needed on a drawing, the draftsman or other person responsible for the numbers goes to the record, takes the first open number for his drawing, and enters appropriate information in the records to indicate what the number is assigned to, who took the number out, and when.

Following this system through the plant in everyday use quickly shows that it has certain drawbacks. In the purchasing group the buyer must study his entire bill of materials in order to collect together like items. To do this he must read the descriptions, and in some cases interpret them. (What do you call the green things that are placed beside the windows on little white cottages? Shutters or blinds?)

Once the materials are ordered, the stock and control groups become involved. As the material arrives, the usual pattern is to arrange it in numerical order. If a serial number system has been used, the stock will consist of a hodge-podge of dissimilar materials arranged in the order employed by the drafting room in making drawings. Imagine a group of tiny precision gears associated with a timing mechanism, costing many dollars each, stocked with raw castings on one side and power transformers weighing 40 pounds each on the other.

After the stock and control people comes the production section, the real reason for all the fuss



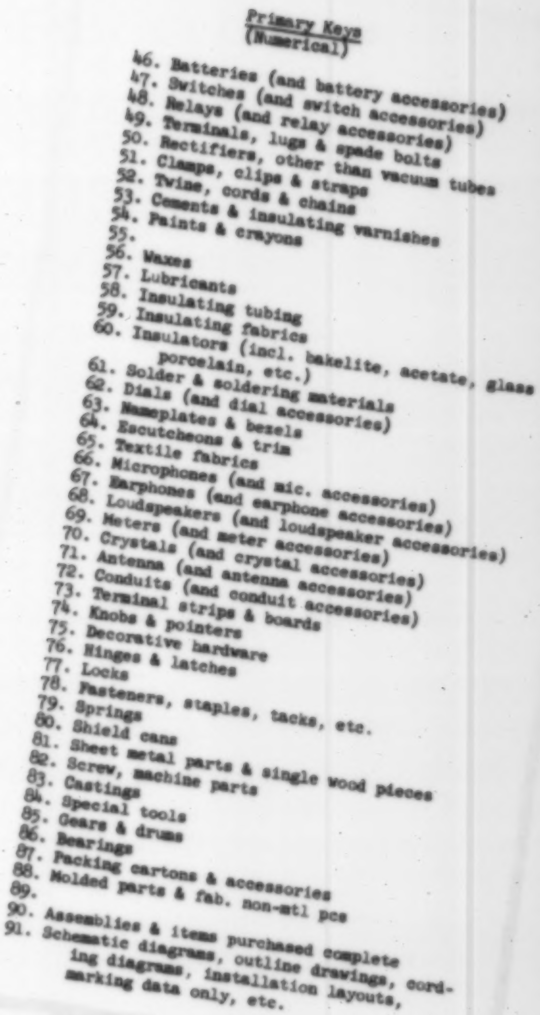
Basic plan of mixed number-letter system for drawings. Part number alone is 81D1028. Dash number suffix is an optional feature allowing for additional coding of part specification.

for identifying parts and drawings within planned classifications built on primary and secondary keys

anyway. Here the features of various methods of numbering have no immediate effect. Assuming that the other groups function in an orderly manner, the material will arrive on the line as required, and can readily be identified for assembly into the equipment. The real trouble comes when something doesn't quite fit, or because of an unexpected shortage of material. Few pieces of equipment have ever been designed that would not stand some substitution, and here is where the serial system of numbering parts invites difficulty. Only by a carefully maintained cross-reference file can substitutes be located on paper, and once the proposed substitute has been chosen, the search through the stockroom begins.

Many hours of direct labor have been wasted because the production men could not go directly to the bins and try similar parts for substitution prior to getting approval for their use. Compare this with a system that stores like material together in the same area, and makes it possible for the expeditor to carry a sample of the short item in his hand directly to the stock bins to compare it with material already on hand.

While the work is in process, and after the actual production is completed, the accounting department must keep constant track of the costs of material and the labor content of each job so that the net results may be ascertained. Production group leaders and foremen are, by nature of their jobs, concerned with getting the work out in the shortest possible time, and are prone to list material and time in the wrong places and against the wrong job number. While a good numbering system is no cure-all for the problems associated with cost accounting, numbers that can easily be identified with



Primary Keys
(Numerical)

46. Batteries (and battery accessories)
47. Switches (and switch accessories)
48. Relays (and relay accessories)
49. Terminals, lugs & spade bolts
50. Rectifiers, other than vacuum tubes
51. Clamps, clips & straps
52. Twine, cords & chains
53. Cements & insulating varnishes
54. Paints & crayons
55.
56. Waxes
57. Lubricants
58. Insulating tubing
59. Insulating fabrics
60. Insulators (incl. bakelite, acetate, glass porcelain, etc.)
61. Solder & soldering materials
62. Dials (and dial accessories)
63. Nameplates & bezels
64. Escutcheons & trim
65. Textile fabrics
66. Microphones (and mic. accessories)
67. Earphones (and earphone accessories)
68. Loudspeakers (and loudspeaker accessories)
69. Meters (and meter accessories)
70. Crystals (and crystal accessories)
71. Antenna (and antenna accessories)
72. Conduits (and conduit accessories)
73. Terminal strips & boards
74. Knobs & pointers
75. Decorative hardware
76. Hinges & latches
77. Locks
78. Fasteners, staples, tacks, etc.
79. Springs
80. Shield cans
81. Sheet metal parts & single wood pieces
82. Screw, machine parts
83. Castings
84. Special tools
85. Gears & drums
86. Bearings
87. Packing cartons & accessories
88. Molded parts & fab. non-mtl pcs
89.
90. Assemblies & items purchased complete
91. Schematic diagrams, outline drawings, cording diagrams, installation layouts, marking data only, etc.

Portion of typical primary key list arranged numerically. This information is developed as the first section of the code master, the index to the identification system.

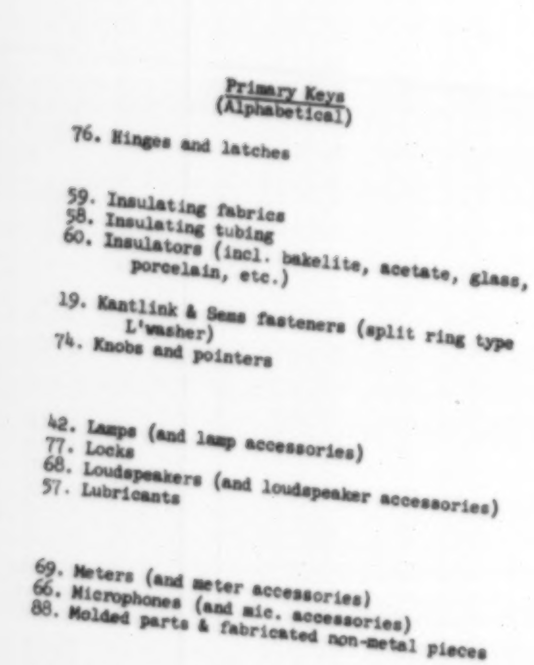
certain types of material, or that will segregate parts and assemblies, can help minimize this type of error and help production workers keep the records straight.

The desired answer is a numbering system that will automatically arrange things in some pattern suitable for use throughout the industry in question. Perhaps the most widely used method of doing this is to code things, using an all-numeric numbering system. One method is to set up a list of categories covering material used in a particular business and arbitrarily to assign a series of numbers to each, for example: 1000 to ac motors, 2000 to dc motors, 3000 to end bells, 4000 to frames, etc. In its basic concept, this pattern is the correct approach; however, there are pitfalls to this method that should be carefully considered before it is adopted.

Dividing the parts and materials used in any given industry into a list of major groups and subdividing these into secondary classifications is a major undertaking. Only a few of the people to whom the task might fall have the ability and broad knowledge of the multiple phases of their industry to do this and cover all the contingencies. Everyone will be faced with the problem of what is going to happen next year and the year after that.

Straight numeric systems of coding is a step in the right direction. However, to allow satisfactory expansion possibilities, it entails long numbers and requires dashes to break up the number into its groupings.

A relatively simple solution to the problems inherent in the all-numeric coding system is to break up the number by the use of letters. Notice the characters used in the dial telephone system. The number 54-3600 is exactly the same as LI-3600. Yet, it is much easier to handle the one with the letters in it.



Primary Keys
(Alphabetical)

76. Hinges and latches

59. Insulating fabrics
58. Insulating tubing
60. Insulators (incl. bakelite, acetate, glass, porcelain, etc.)

19. Kantlink & Sems fasteners (split ring type L'washer)
74. Knobs and pointers

42. Lamps (and lamp accessories)
77. Locks
68. Loudspeakers (and loudspeaker accessories)
57. Lubricants

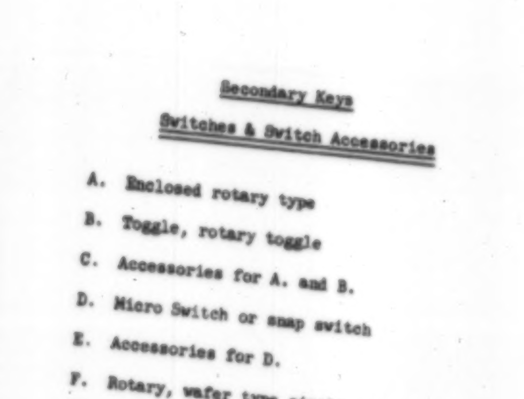
69. Meters (and meter accessories)
66. Microphones (and mic. accessories)
88. Molded parts & fabricated non-metal pieces

63. Nameplates and bezels
20. Nuts
21. Nuts, self-locking
22. Nuts, special

87. Packing cartons and accessories
54. Paints and crayons
36. Pins (tube pins, etc.)
17. Plugs

93. Ref. data sheets
50. Rectifiers, other than vacuum tubes
48. Relays (and relay accessories)

Portion of primary key list arranged alphabetically for convenient cross-reference with numerically arranged primary list. As in a library system, alternate designations are also included in order that primary keys can be identified from different possible titles.



Secondary Keys

Switches & Switch Accessories

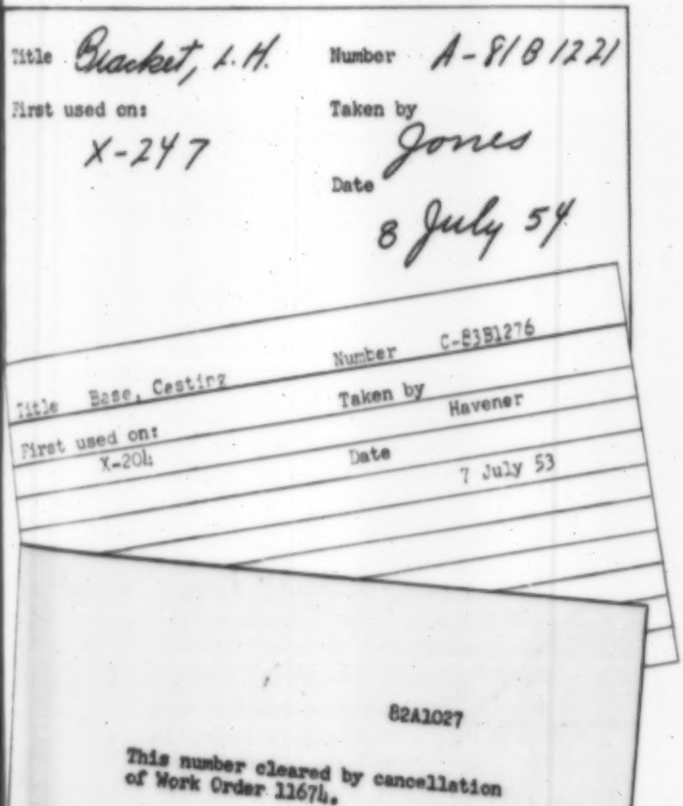
A. Enclosed rotary type
B. Toggle, rotary toggle
C. Accessories for A. and B.
D. Micro Switch or snap switch
E. Accessories for D.
F. Rotary, wafer type single and multiple gang
G. Accessories for F.
H. Potentiometer (snap-on)
J. Pushbutton (see T)
K. Mercury
L. Slide
M. Interlock
N. Telegraph key
P. Thermostats & self acting
R.
S. Contacts, stock & special (see also 48B)
T. Accessories for J.
U.
V.
W.
X.
Y.
Z. Special

A typical secondary key list. In this case the primary key is 47—Switches and Switch Accessories. The letter system allows at least 23 secondary categories (omitting letters I, O and Q).

Consider, too, the coded number for a gear: let the all-numeric number be 12000 for gears, 12100 be for gears, spur; 12110 be for gears, spur, fine-pitch. This leaves only nine possible variations to take care of all spur gears, fine-pitch, on which records will be accumulated over a period of years. Since this is obviously impractical, the part number might be increased to seven characters to allow more room for expansion. This new approach gives a number 1211000 and allows 999 variations of fine-pitch spur gears.

Using the some number of characters, but with a mixed number-letter pattern, would work out something like this: 12 for gears; A for fine-pitch spur gears (B would be for standard-pitch spur gears). Four digits would be left to cover the possible variations in the gears. The number would look like this: 12A1000.

Already the capacity of the number has been enlarged without making the number itself any larger. Within this pattern there are even greater expansion possibilities since the secondary key, the letter A, while requiring only one space, can be changed to cover 23 categories (avoiding the letters I, O and Q since they are so readily confused with the numbers 1, 0 and 2).



Title Bracket, L.H. Number A-81B1221

First used on: X-247

Taken by Jones

Date 8 July 54

Title Base, Casting Number C-83B1276

First used on: X-204

Taken by Havener

Date 7 July 53

82A1027

This number cleared by cancellation of Work Order 11674.

Typical cards from the file of actual drawing numbers. The top card, of a special color, is the temporary record made by the draftsman at the time he takes out the number. Later this card is replaced by a typed permanent card. The center card, usually of white stock, typifies a permanent record. The bottom card, of still a different color, represents a numbe available for assignment to a new part.

Look back at that all-numeric number for a moment. What happens when 99 categories have been used for a primary key? Can three digits be used, or will people start taking the last number of the primary key for the first number of the secondary classification? Dashes could be added to break up the number, but this isn't a happy answer. With the mixed system, it makes no difference to the pattern whether the primary key is one digit or ten, nor for that matter does it make any difference if the secondary key itself has to be expanded to two or more digits. What are the keys in the two numbers 4358279476 and 536BFK5789?

Setting up a coded numbering system takes time and careful thought. It should not be attempted on a crash basis, but there is no need to be frightened by the size of the task. If the basic plans are well made at the start, categories that are overlooked and subclassifications that slipped by can be inserted later without difficulty.

The first step is to set down a list of all the major divisions of material handled in a given industry. The examples shown here are for an electronics manufacturing company, but the pattern is adaptable to any industry. After primary classifications are listed, each should be broken down into its subcategories. Listing the primary and secondary categories is the biggest part of the job. Next it is only necessary to assign numbers and letters to the classes of material.

Convenience in the drafting room files where tracings cannot be folded for storage makes it desirable to have the drawing size indicated in the part number, and the letters A, B, C, etc., to indicate 8½ by 11 inches, 11 by 17, 17 by 22, etc., tracings is so universal that it might as well be the start of the number. (If this is done, instructions should be issued to everyone handling part numbers to ignore this letter in arranging the part numbers in order on lists, etc.)

The primary key is then numerical. It is well to allow twice as many primary keys as needed at the moment. This allowance for expansion sets the range of the primary key. One way to reduce typing troubles is to keep the total number of characters in the part number as near constant as possible. That is, if the list requires three digits, it should be started with 100, and the numbers 99 and below should not be used.

The secondary key should be set up next. The list should be checked for the largest number of subdivisions. Here letters will be used. The number of spaces required should be checked keeping in mind that each space can represent 23 categories. Also, here again uniform size is desirable, and if two spaces are required in some groupings, two spaces should be used in all groupings.

Serial numbers will comprise the balance of the part number, although in some cases coding can be even further extended. Here a liberal number of spaces should be allowed, but it should be remembered that the serial numbers will be applied to only one subdivision of each primary heading. A good size number is one with four characters, allowing 9999 numbers under each secondary key. Here, it may be desirable to start with 0001.

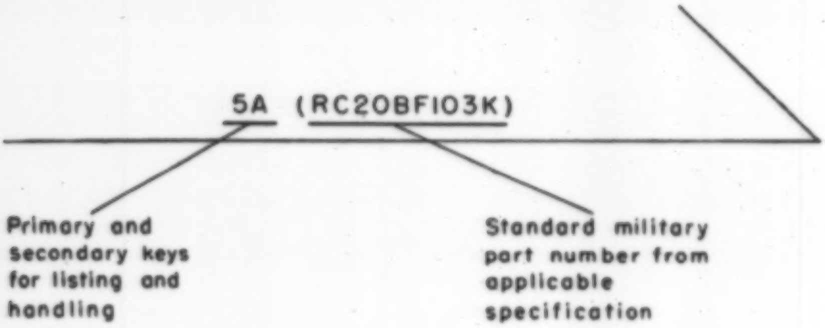
Keeping the number a uniform size is a good idea because the number will be transcribed many times before the equipment is out the door. Every provision to prevent errors, or to make them more easily recognizable, improves the efficiency of the organization. Transposing of figures or letters or omission of characters, are kinds of mistakes that can often be spotted with a uniform-length number-letter system.

Numbering a drawing should be the job of the draftsman who is working on the drawing. No one in the plant is in any better position to decide where it belongs in the classifications. A good arrangement to make number taking easy is to set up a white card file of the drawing numbers arranged in their numerical-alphabetical sequence, with a supply of colored cards (pink, for example) handy. When the draftsman needs a new number, he goes to the card file, looks up the highest number in the primary and secondary classification he wants, assigns the next serial number to his drawing, placing the data on a colored card, and places it in its proper place in the files. The clerk assigned to the files checks regularly for colored cards, removes them, and replaces them with typed white cards.

The white card can well be the type used in libraries with the hole in the bottom so it cannot be removed from the files. A card of a different color such as blue can be used to indicate an open number that has been skipped or discontinued for any reason. The blue card is an indication to the draftsman that a particular number is open and can be assigned to a new drawing.

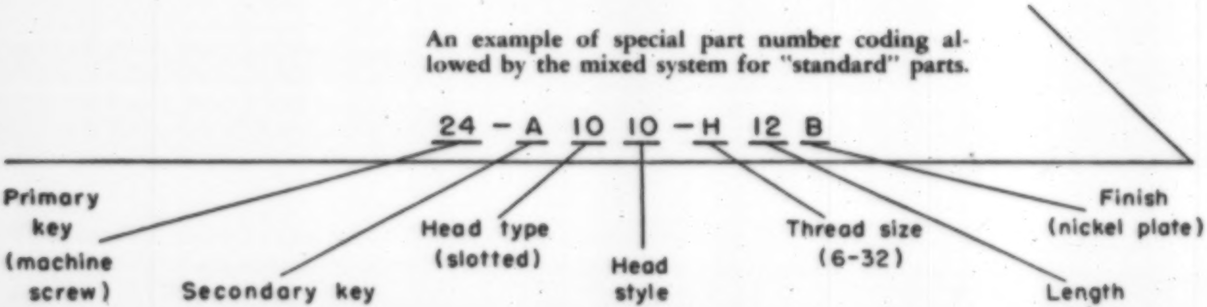
A code master is prepared to support the drawing number file. The purpose of this master is to record for easy reference the primary and secondary key designations that have been established for the code. In the front of the code master, a simple listing is made in numerical order of the primary keys used, and a short title for each one. Immediately after this numerical index, an alphabetical index of subject matter is provided with the appropriate primary key number listed. Here there are also listed as many alternate subjects for cross reference as can be thought of. (Such as Blinds, see Shutters)

The body of the code master consists of pages representing each primary key, on which are listed the secondary keys. In some cases, where it is of advantage to further break down the coding of a part number, an explanation is included on the page covering the primary key. An example of further coding would be machine screws. The first two digits of the serial number can represent the head type, and the second two digits can represent the head style, with the size, length and finish covered by the dash number.


5A (RC20BF103K)
Primary and secondary keys for listing and handling
Standard military part number from applicable specification

Left—A method for building customer or military numbers into the mixed system.

An example of special part number coding allowed by the mixed system for "standard" parts.



Copies of this code master should be made available to each draftsman, and to everyone in the plant who heads up a group dealing directly with material. After the system is well established, standards can be added to the master.

This method of numbering, carefully planned, works equally well for small and large plants. In a small plant, it is important to recognize that business operation may expand significantly and rapidly. A pattern of numbering drawings that can without hesitation double and triple its capacity and still provide quick cross reference to all that has gone before is invaluable. By the same token, a system in a large plant that will simplify the cross checking of the work of different groups is also invaluable.

In a large plant, it may be necessary to set up a small group to check the code master at regular intervals, adding and correcting as needed, and instructing new men in the proper use of the facilities. In all probability some modification to the base pattern would have to be made to cope with the very large number of drawings that are used in a large engineering group. A possible plan would be to screen drawings to use for reference on future jobs, dead file the balance, and by so doing reduce the size of the reference files.

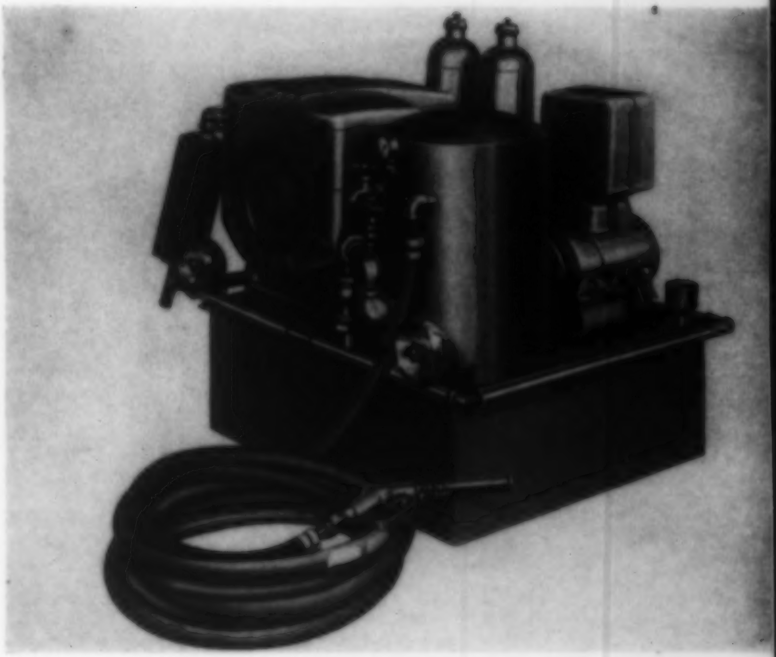
In a multiplant operation, problems become compounded, but the solutions are no more involved than for the basic system. Addition of a key for each branch, to identify where the design originated, and sending a copy to the main plant for screening and incorporation into a master drawing file for use by all branches for future reference, would fill the bill nicely. Some parts would be peculiar to the branch, but many would be useable by other branches and should be made available to them under one base number. The codes used in all branches should be similar setups, but must of course be arranged so that two plants can not assign the same number to two different pieces.

CONTEMPORARY DESIGN

Versatile Unit Fights Fires, Provides Power

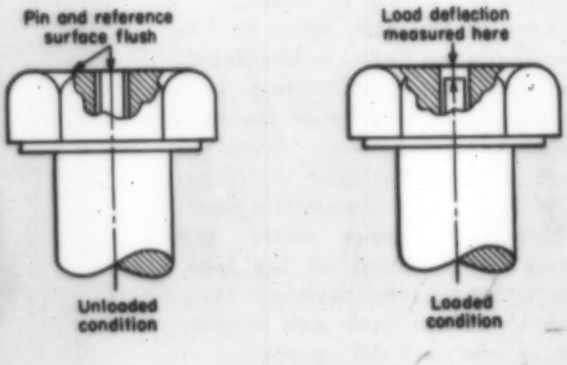
A COMPACT, portable unit, designated Versatile Power provides electrical power for emergency lighting or operation of portable electric tools. Additionally, it is a piece of fire-fighting equipment having an integral 55-gallon water tank, pump and equipment to mix a penetrant with the water in proper proportion. The penetrant, Unox, improves the fire extinguishing ability of water.

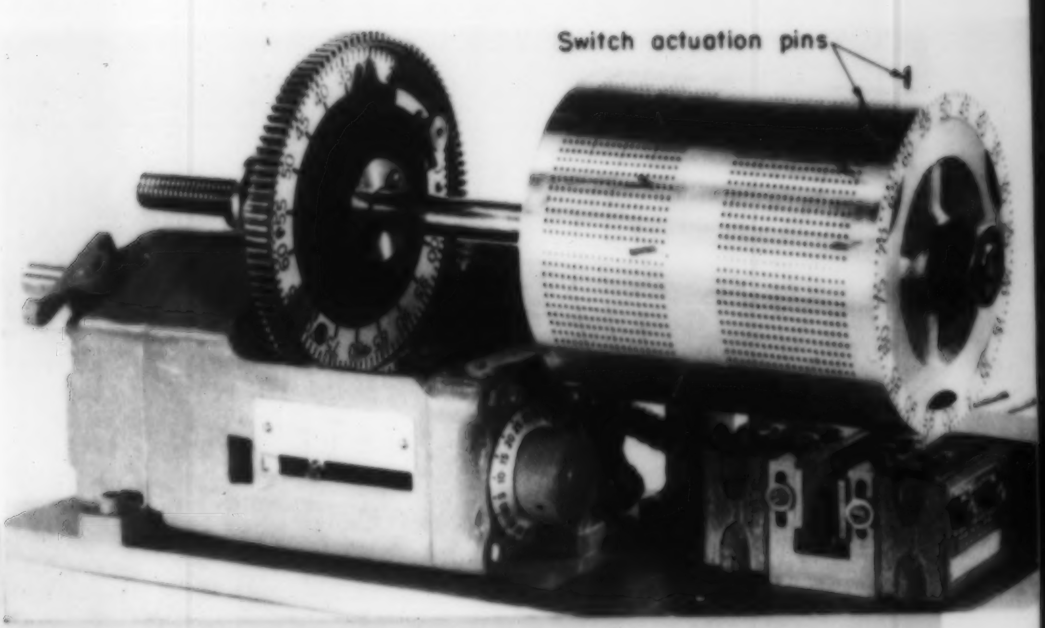
Base of the unit, made by National Alarms Corp., is the 55-gallon water tank. Carrying bars welded to three sides of the base make it easy to load, unload or carry the unit for short distances. A 3500-watt gasoline-electric plant, 2-horsepower pump motor and pump are mounted on the base. Spotlights on the carrying bars, and the Unox tank and proportioner, complete the assembly.



scanning the field for Ideas

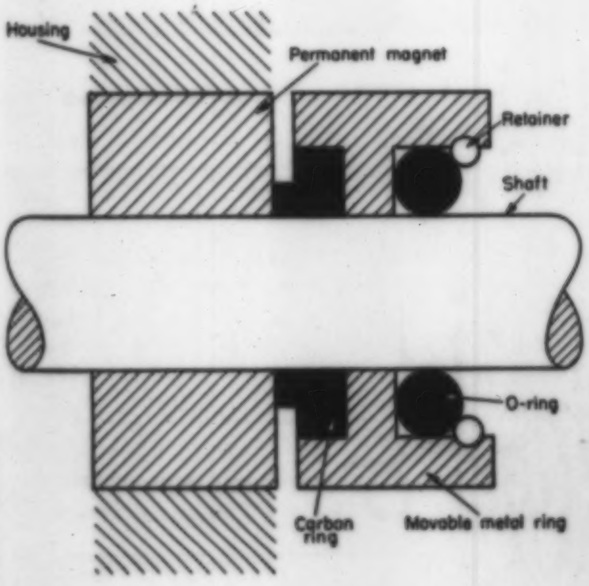
ACCURATE PRELOADING of bolted assemblies is obtained with a bolt shank design which incorporates a built-in "strain gage." Developed by the Precision Threaded Products Div. of the Bland Burner Co., the design utilizes an unstressed reference pin to permit direct measurement of bolt elongation under load. The metal reference pin is mounted in a hole along the bolt axis and is held in position by a press fit at the inner end. When the bolt is unloaded, the free end of the pin and the top surface of the bolt head lie in the same plane. Under load, however, the bolt shank stretches, changing the relative position of these two reference surfaces; the end of the pin then represents the original unstressed length. Thus, the actual tensile stress on the bolt shank can be determined directly by measuring the elongation and translating that reading into stress, or by using a direct-reading stress gage.

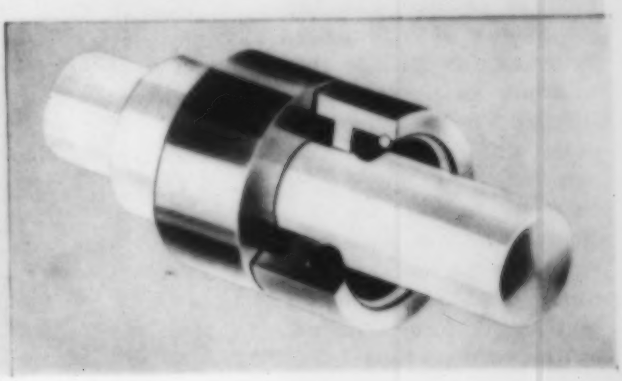

Pin and reference surface flush
Load deflection measured here
Unloaded condition
Loaded condition



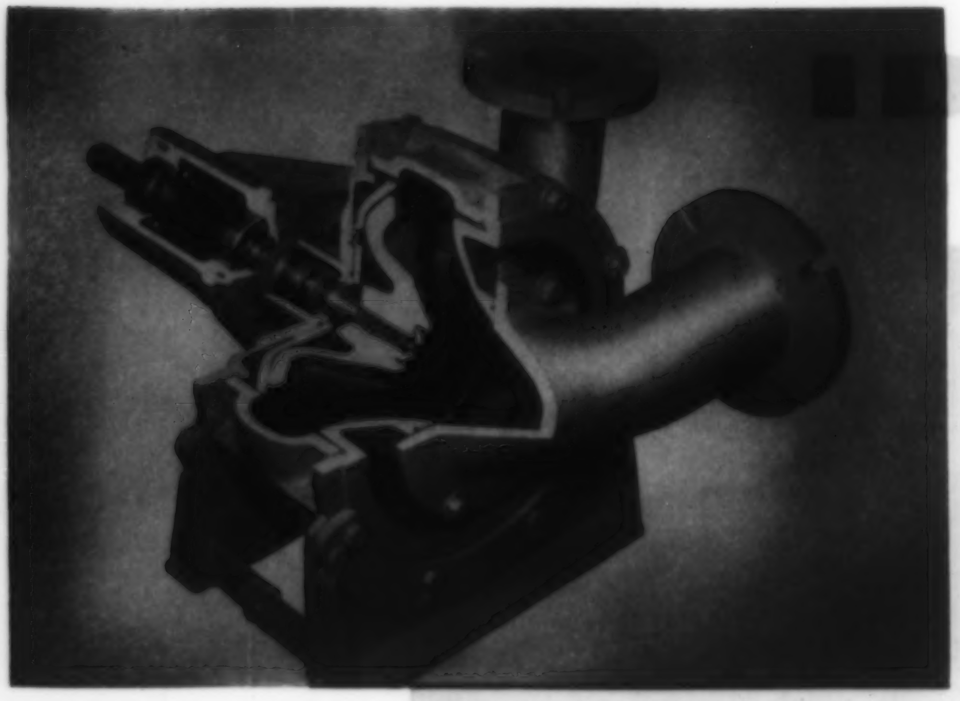
VARIABLE PROGRAMMING REQUIREMENTS of electric switch circuits can be met with a novel rotating control system arrangement. In a combination automatic counter and circuit controller developed by the Counter and Control Corp., small metal pins in a perforated programming cylinder mechanically actuate precision snap-action electric switches according to any desired preset pattern arrangement. These pins are self-locking, and can be easily removed and rearranged to meet varying switching requirements. Operation of the cylinder is based on a count cycle; each hole represents one count. The design is particularly suitable for applications where switch functions must occur at irregular intervals in a repeating cycle.

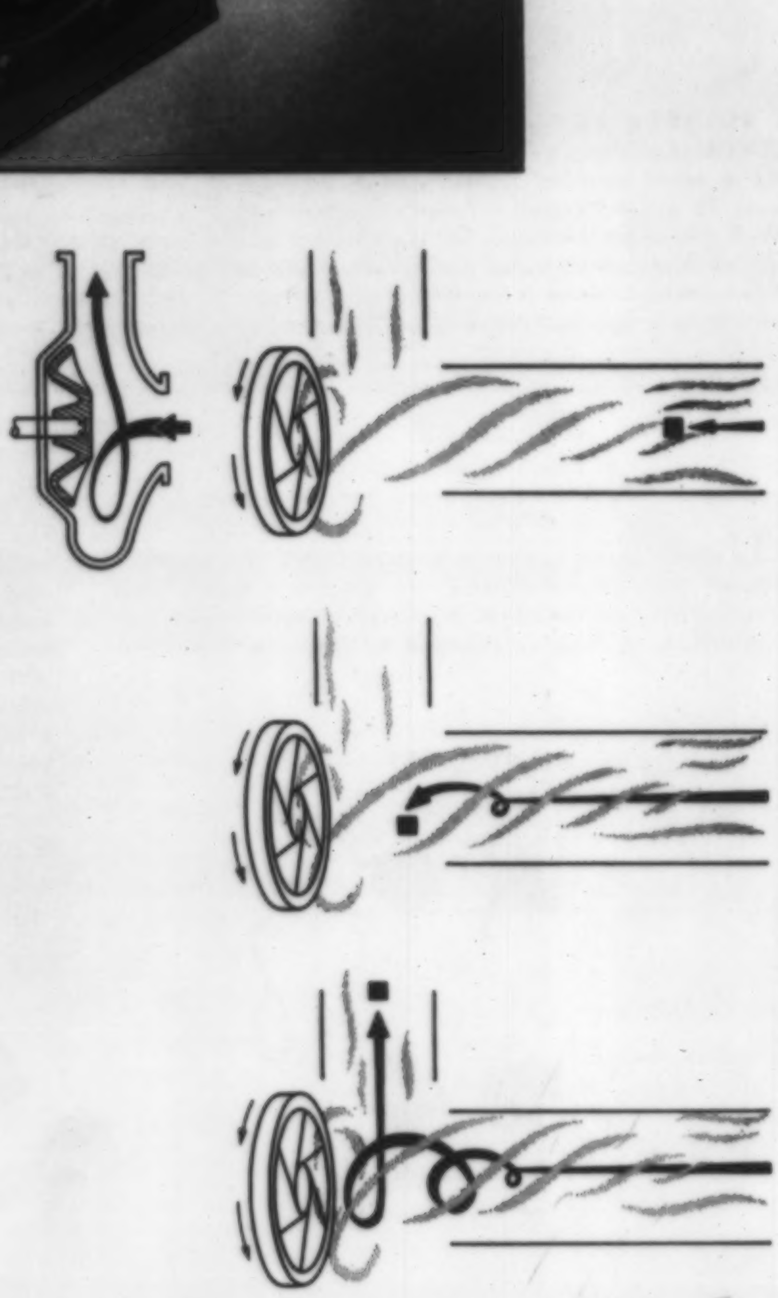
UNIFORM SEALING ENGAGEMENT via magnetic force principles eliminates the need for conventional spring-loading means in a two-piece rotary seal construction. A design developed by Magnetic Seal Corp. employs a permanent magnet ring fixed to the housing and axially-movable metal ring mounted to the rotating shaft with an O-ring. The magnetic attraction of the ring magnet holds the movable metal ring in position and maintains uniform distribution of pressure on the contact surfaces to assure proper operating alignment.





IDEAS





SWIRLING LIQUID VORTEX forms the carrying medium in a unique solids pump developed by the Western Machinery Co. The pump allows material of all sizes, shapes and degrees of durability to pass through the pump without jamming, clogging, breaking, crushing or binding. Such diverse solids as coal, gravel, live fish, cherries, rags, garbage, paper pulp, etc., have been successfully pumped.

The high-speed rotation is created by a novel impeller which is recessed within the pump case and is essentially out of the flow path. This vortex or swirl is induced into the whole mass of fluid inside. Solids are swept into this rotation and are passed through the housing and outlet with little or no contact with the rotor unit. Particles usually are discharged in less than one revolution of the swirl because of the amount of centrifugal force induced by the vortex action.

Contributory Patent Infringement

How the new Patent Act protects the component parts of a patented invention.

By Albert Woodruff Gray
*Jackson Heights, L. I.
New York*

THE Senate Report on the bill that became the present Patent Act in 1952, states in part, "The doctrine of contributory infringement has been a part of our law for eighty years. It has been applied to enjoin those who sought to cause infringement by supplying someone else with the means and directions for infringing a patent.

"One who makes a special device constituting the heart of a patented machine and supplies it to others with directions (specific or implied) to complete the machine, is obviously appropriating the benefit of the patented invention.

"It is for this reason that the doctrine of contributory infringement, which prevents appropriating another man's patented invention, has been characterized as 'an expression both of law and morals.'

"Considerable doubt and confusion as to the scope of contributory infringement has resulted from a number of decisions of the courts in recent years. The purpose of this section is to codify in statutory form principles of contributory infringement and at the same time eliminate this doubt and confusion.

"The sale of a component part of a patented machine, etc., must constitute a material part of the invention and must be known to be especially adapted for use in the infringement before there can be contributory infringement, and likewise the sale of staple articles of commerce suitable for noninfringement use does not constitute contributory infringement."

Legal Precedent: A decision to which this Senate Report undoubtedly referred in its comment, that this principle had been part of our law for eighty years, was made by a Federal court in 1871, in relation to the patent of an oil burning lamp. After this patent had been granted, another manufacturer undertook the manufacture and sale of burners substantially identical to those covered by the patent of this lamp. The patent, however, covered the whole lamp.

In its defense to the action for infringement, the manufacturer of this burner maintained that the patent had been granted for a combination of several parts which constituted a lamp only after they were assembled and its own manufacture of merely one of those parts consequently did not infringe the composite article that had been patented.

In its decision of this early case, from which was apparently derived the principle of contributory infringement, the Federal court said: "If in actual

"Whoever actively induces infringement of a patent shall be liable as an infringer."

"Whoever sells a component of a patented machine . . . constituting a material part of the invention, knowing the same to be especially made . . . for use in an infringement of such patent . . . shall be liable as a contributory infringer."

". . . unpatented components of a patented combination, which wear out quickly, as compared to the life of the combination as a whole, may be replaced without infringement."

Not only must the infringer intentionally plan and intend to violate the rights of the patentee in his invention but the act must have for its purpose the construction and not the mere repair of a patented article.

concert with a third party with a view to the actual production of the patented improvement in lamps, and the sale and use thereof, they consent to manufacture the burner, and such other parties to make the chimney and in such concert they actually make and sell the burner, and he the chimney, each utterly useless without the other, and each intended to be used, and actually sold to be used, with the other, it cannot be doubtful that they must be deemed to be joint infringers of this patent.

"It cannot be that where a useful machine is patented as a combination of parts, two or more can engage in its construction and sale, and protect themselves by showing that, though united in an effort to produce the same machine, and sell it, and bring it into extensive use, each makes and sells one part only, which is useless without the others, and still another person, in precise conformity with the purpose in view, puts them together for use.

"If it were so, such patents would indeed be of little value. In such cases all were wrong doers, engaged in a common purpose to infringe a patent, and actually by their concerted action, producing that result."

Present Interpretation: Congress, eighty years after this decison was rendered, enacted the present patent law which provides in relation to contributory infringement, "Whoever actively induces infringement of a patent shall be liable as an infringer.

"Whoever sells a component part of a patented machine, manufacture, combination or composition, or a material or apparatus for use in practicing patent process, constituting a material part of the invention, knowing the same to be especially made or especially adapted for use in an infringement of such patent, and not a staple article or commodity of commerce suitable for substantial noninfringing use, shall be liable as a contributory infringer."

A characterization by a Federal court of this offense is, "Intentional aid or cooperation in transactions which collectively constitute complete infringement. Where a person furnishes one part of a patented combination, intending that it shall be assembled with the other parts thereof, and that the complete combination shall be used or sold."

This however, was qualified by the court with the further statement, "Before one can be held for contributory infringement he must knowingly have done some act without which the infringement would not have occurred. At least, either he must know that the element that he sells will be used in the patented combination or the element must be adapted to no other use."

Legal Principles: A few years ago a Federal appellate court set out the features of contributory infrigement in a concise interpretation of this new provision of the present Patent Act: "To establish contributory infringement the following facts must appear: (1) a valid patent, (2) ordinarily in the case of a product, a patent covering a combination, (3) the alleged infringement must make or supply one or more of the elements of the combination with the knowledge and intention that the same is to be used in the patented combination.

"Contributory infringement is the outgrowth or result of the application of the following legal principles:

1. "A patentable combination is a unit in the contemplation of the law.
2. "Some elements of the combination may be old and others new, or all old or all new.
3. "One who takes, sells or uses the combination without permission of the patentee is an infringer.
4. "One may be a contributory infringer although he makes, sells or uses an element that is old and not covered or coverable by a patent.
5. "When the manufacturer makes, uses or sells an unpatented (or old) element, he becomes a contributory infringer only when the element is knowingly made, sold or to be used as a part of a patentable combination without the patentee's express or implied consent."

Boundaries of Liability: Not only must the infringer thus intentionally plan and intend to violate the rights of the patentee in his invention but the act must have for its purpose the construction and not the mere repair of a patented article.

This rule was laid down by the Supreme Court of the United States in the decision of a suit, in the middle of the last century, brought by the patentee of a planing machine. It was contended that the substitution, by the owner, of new blades or knives for those that had been worn in one of these machines was not a repair but the reconstruction of the machine and an infringement of the patent.

"The right to repair and replace is either in the patentee or in him who has bought the machine," asserted that court. "Has the patentee a more equitable right to force the disuse of the machine

". . . the right to renew depends upon the right to make the invention, and if the right to make does not exist, there is no right to rebuild the combination."

entirely, on account of the inoperativeness of a part of it than the purchaser has to repair, who has in the whole of it a right of use.

"We deem that when the material of the combination ceases to exist, in whatever that may occur, the right to renew it depends upon the right to make the invention, and if the right to make does not exist, there is no right to rebuild the combination.

"But it does not follow when one of the elements of the combination has become so much worn as to be inoperative, or has been broken, that the machine no longer exists for restoration to its original use by the owner who has bought its use. When the wearing or injury is partial then repair is restoration and not reconstruction."

Case Examples: A practical illustration of this principle that distinguishes between replacements or repairs, which may be legitimately made by the owner of a patented article, and the acts of a contributory infringer who seeks to ride on the running board of another's invention, occurred in the decision of a case before a Federal court, involving the manufacture and sale of unpatented razor blades for use with a patented safety razor.

"The rule has long been recognized," said the court in its decision of this action for contributory infringement, "that unpatented components of a patented combination, which wear out quickly, as compared to the life of the combination as a whole, may be replaced without infringement. The reconstruction of a patented article which has already received its complete, normal and intended use, or the sale of an unpatented component of a patented combination, which is not merely a repair but is a substitute or addition to a part supplied by the patentee embodying the most important features of the invention, constitutes infringement."

Then, referring particularly to the use of these unpatented razor blades, the court continued, "Admitting that the original blades supplied by the manufacturer of this razor might last longer if resharpened, the fact is that the great majority of users discard them without resharpening. Since one buyer may discard his blades after a few sharpenings and another may not, we find no intent of the manufacturer of this patented razor to prevent the buyer from replacing blades for all practical purposes worn out, merely because they might stand another resharpening. Although they will stand some resharpening, many describe them as worn out after use without resharpening."

In sharp contrast with the conclusions of the court in this case and its application of the law of contributory infringement, is the decision of another case in which the owner of the patents for the familiar disk phonograph records sued in the federal court for an injunction against another manufacturer of disk records of the same type as those covered by these patents. The injunction against this infringing manufacturer was granted and later followed by an application for punishment for contempt. The contributory infringer contended that it was merely selling a substitute for worn out records.

"This," said the Federal court, "seems to be a case of contributory infringement—an entirely voluntary and intentional one, not in any wise excused by the circumstances. Nor is the substitution of these new records, bought more frequently in order to increase the repertory of tunes than as substitutes for worn out disks, in any legitimate sense, 'repairs.' "

This decision was later affirmed by the United States Supreme Court with the comment, "A combination is a composition of elements, some of which may be old and others new, or all old or all new. It is however, the combination that is the invention and is as much a unit in contemplation of law as a single or noncomposite instrument. Whoever uses it without permission is an infringer of it. Whoever contributes to such use is an infringer of it. It can make no difference to the infringer or noninfringer of a combination that one of its elements or all of its elements are unpatented."

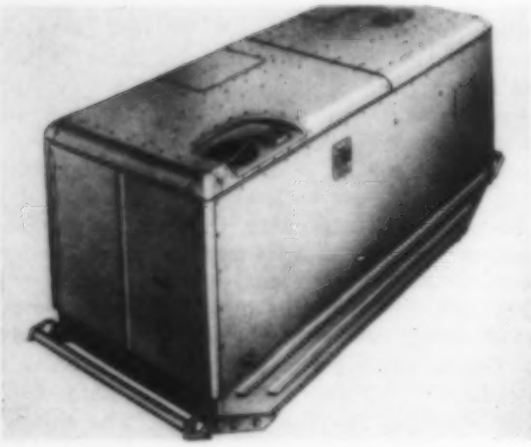
REFERENCES

1. Senate Report, No. 1979, June 27, 1952
2. Wallace v. Holmes, 29 Fed. Cas. 74
3. 35 U.S.C.A., sec. 271 (b), (c)
4. Detroit Lubricator Co. v. Toussaint, 57 F.S. 837
5. Wilson v. Simpson, 50 U. S. 109
6. Gillette Safety Razor Co. v. Standard Safety Razor Co., 64 Fed. 2d 6
7. Leeds & Catlin Co. v. Victor Talking Machine Co., 213 U. S. 325, aff'g. 154 Fed. 158
8. Lincoln Engineering Co. v. Stewart-Warner Corp., 91 Fed. 2d 757

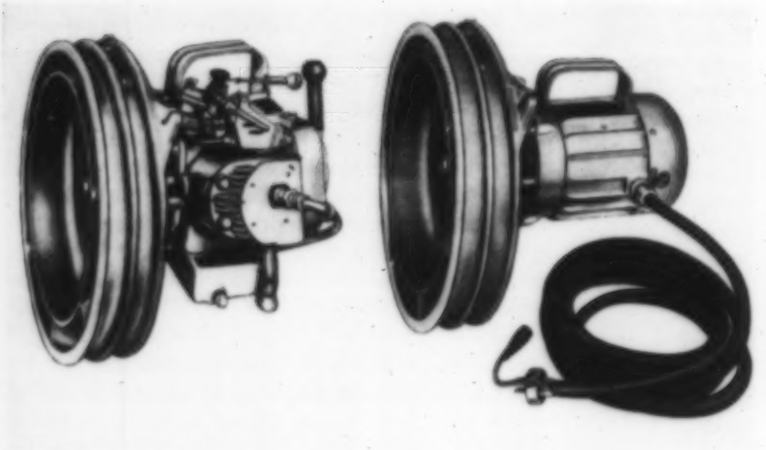
"It can make no difference to the infringer or noninfringer of a combination that one of its elements or all of its elements are unpatented."

". . . the alleged infringement must make or supply one or more of the elements of the combination with the knowledge and intention that the same is to be used in the patented combination."

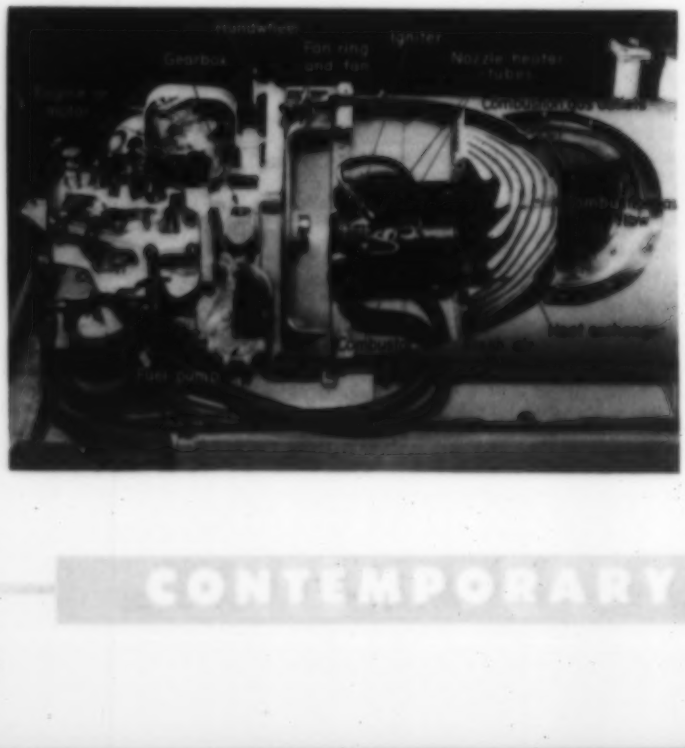
Quick Change Power Units Provide Heater Versatility



FAST, simple interchangeability of two prime-mover units—one a gasoline engine, the other an electric motor—increases utility of a portable, gasoline-burning heater. According to the manufacturer, Herman Nelson Div., American Air Filter Co. Inc., the changeover can be accomplished in a matter of seconds and can be done with no tools. Output is variable from 125,000 to 400,000 Btu per hour. Discharge air temperature can be regulated between limits of 150 and 280 F. Skid base of the unit also serves as a fuel tank which has capacity for 4 hours of operation at full rated output. The unit is 50 inches long, 20 inches wide and 24 inches high.



Interchangeable prime mover units include 2-hp gasoline engine or 115-v, 60-cycle, 2-hp electric motor, a gearbox to drive the fuel pump and magneto, and a fan ring and fan. Removal or installation of either unit is simple since it is held in place by a groove, which mates with the fan ring, and two handwheels. Only other operations necessary are connection or disconnection of the engine fuel line and the exhaust line. A quick-disconnect fitting which is self-sealing when disconnected takes care of the fuel line. Connection and disconnection of the exhaust line is automatically performed by what might be described as a mating ball and funnel in the exhaust line.



Heat exchanger design, described as a radial airfoil type, results in 75 per cent of the heat content of the fuel being transferred to the heated fresh air when initial air temperature is −65 F. Hot gases from the combustor pass through the air-foil shaped passages in a radial direction until exhausted at the thin "trailing edge" outlets. Fresh air moves axially, through similar airfoil-shaped tubes, to the outlet. Another interesting detail of the design is that the combustor nozzle does not "ice" even at −65 F in dense ice fogs. Nozzle icing in extremely cold weather has been a very serious problem.

Multiple-
Circuit
Switches

Selection Factors

By Keith A. Carlson
Associate Editor
Machine Design

Manually operated, multiple-circuit switches are of three primary types—(1) lever (2) rotary, and (3) push or pull-operated switches. Physical and electrical characteristics of these switches have been considered in previous parts of this series of articles, MACHINE DESIGN, October, 1954, January and April, 1955. This article discusses factors to be considered when selecting switches from these types for a specific application

SELECTION of a switch for a specific application from the types described in the earlier articles in this series is based upon various interrelated factors. Those which are usually applicable in any situation are:

1. Current and voltage ratings
2. Required switching arrangement
3. Size and weight
4. Cost
5. Operating conditions
6. Required life
7. Operator convenience
8. Safety
9. Appearance

No attempt has been made to list these factors in relative order of importance, although 1 and 2 must certainly be satisfied before any consideration is given to the relative importance of the others.

Since a selection factor which may be of extreme importance in one instance may be of no concern in another, hard and fast rules based upon the

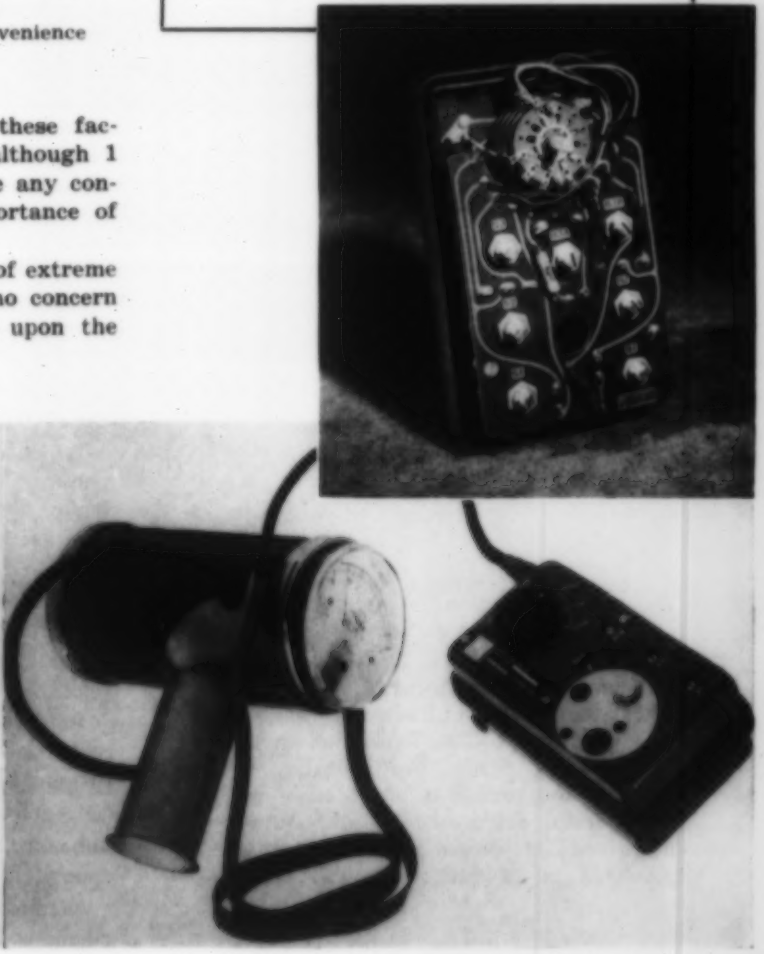


Fig. 1—Small size, low weight and fairly complex switching requirement dictate use of a wafer-type rotary switch in the control unit of this beta-gamma radiation monitor manufactured by Jordan Electronic Mfg. Co. Inc. Complete unit includes gun meter chamber and control box, right. Control unit removed from its case, right above, shows small size and complexity of the switch. The complete control unit measures 5¾ by 3½ by 2¼ inches and weighs 2 pounds

Fig. 2—An automatic tester for rapid production testing of complex electronic and electrical units uses wafer-type rotary switches to complete circuits for as many as 1000 different tests. Switches are contained in an adapter unit, right, which attaches to the top of the main unit, left. Small size, circuit complexity and reliability were reasons for selection of switches of this type by Color-Television Inc. engineers

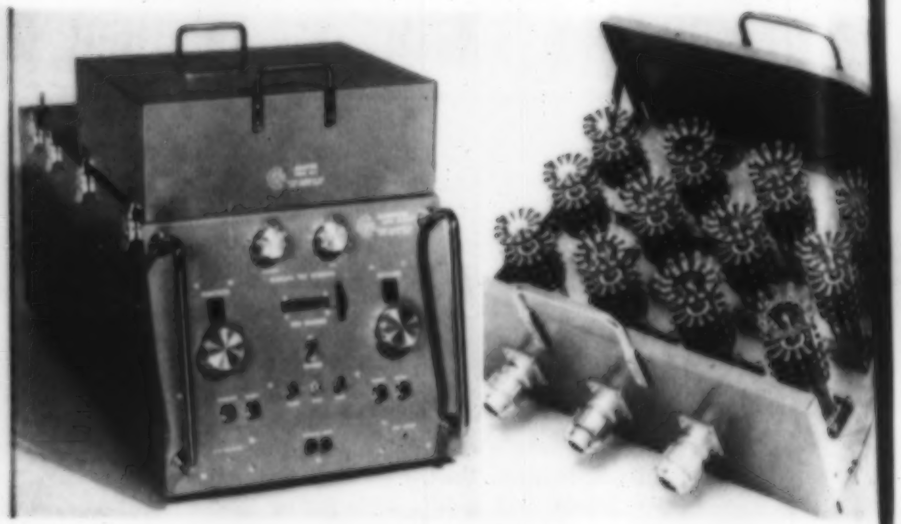


Fig. 3—Front of panel area requirement is minimized by using a single drum switch (arrow) to control this Steinle centerless thread generator. The switch starts and stops three motors driving spindles, hydraulic pump and coolant pump. Additionally, it controls the direction of rotation of the spindle drive motor, and movement of a thread-generating roll mounted on a heavy dovetail slide

listed selection factors cannot be established. Discussion will, therefore, be confined to reasons for the importance of these factors, what the designer should know to properly evaluate them, and the effect of each upon one or more of the others.

Current and Voltage Ratings: Although selection of a switch with proper ratings appears to be simply a matter of consulting catalog data, some discussion of rating significance may be in order. In at least some instances, switch ratings are based upon expected contact life as measured by the number of times the switch is operated. Frequency of operation may also affect contact life and, therefore, electrical ratings. So the designer should be sure that switch ratings are valid for the frequency of operation and life requirement of a particular application.

Alternating-current ratings are usually based upon a normal current frequency of 60 cycles per second. If appreciably higher or lower frequencies are involved, investigation of ratings for that frequency are in order. An extreme example of rating variation with current frequency variation is obtained by comparing dc (zero cycles per second) ratings with ac ratings. Ratings for dc service are always much lower since dc current tends to arc across the contact points to a much greater extent than ac. This is because ac potentials or voltages are zero during a portion of the cycle while direct voltage remains constant or may even increase while a switch is opening.

Ratings are also affected by the type of load. Manufacturers ratings take this factor into account and are based upon inductive or noninductive loads. Noninductive loads are further broken down into resistive and lamp loads.

Inductive loads include motors, solenoids, relays, coils and other electromagnetic devices. Switch ratings for inductive loads are lower than for resistive loads when dc is involved, because voltage induced in the inductive load when switch contacts open may be many times greater than normal.

Noninductive loads include heaters, rheostats, incandescent lamps and electronic tube filaments and heaters. All of these are essentially resistive loads. However, incandescent lamps and tube filaments and heaters fall into a separate classification labelled lamp loads. Ratings for lamp loads are lower than for other resistive loads because resistance of a cold filament is much less than the heated filament. This results in much higher current during the time the filament is heating than that which flows when the filament is hot.

Required Switching Arrangement: This factor, more than any other, may force the designer to chose a particular type of switch from the three basic groups—lever-operated, rotary and pushbutton. Switching arrangements commonly available in one group may be obtainable in another only at excessive cost or in a prohibitively large package, if available at all.

Of the three basic types, rotary switches seem to offer highest versatility in the smallest package. Multiple-pushbutton switches, of course, also offer extreme versatility. However, more complex contact arrangements are usually obtained by actual addition of another switch unit which is mechanically interlocked with the other pushbuttons. Upper limits of switch complexity for the three switch groups are:

1. Lever switches: Five positions with no well defined practical limit to the number of poles.
2. Rotary switches: Sixty or perhaps more positions in a single wafer or deck used as a single pole switch. Poles per deck may be increased by reducing positions. Number of decks per switch can be higher than 24.
3. Push or pull types: Maximum of four positions per switch unit, usually. Poles per switch unit may equal 20 or more. Switch units may be mounted on common frame and mechanically interlocked to produce very versatile assemblies.

Size and Weight: Type of duty for which a switch is intended, contact ratings, and the complexity of the switching arrangement all affect size and weight. Cost, of course, will probably be increased, if extremely small size and low weight are required. For fairly complex switching arrangements, rotary switches appear to offer

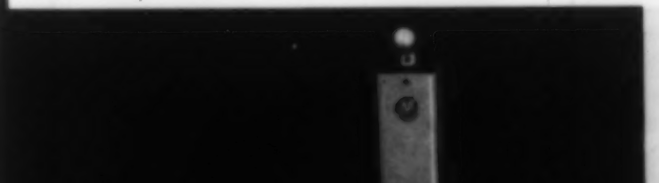


Fig. 4—Above—Small conduit-mounted drum switch provides convenient control for the two-speed two-winding, three-phase motor of a South Bend lathe. The switch is used to select either of two forward speeds or reverse

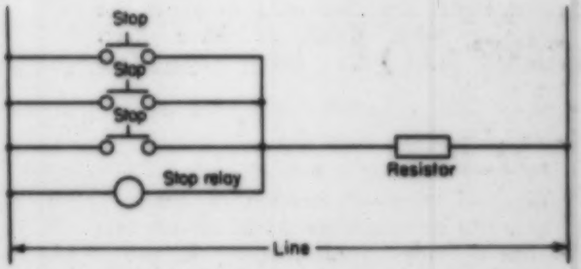


Fig. 5—Above—For operator convenience and safety, it may be desirable to have *stop* switches located at several points about a machine. If the number were small, all switches could be normally-closed and wired in series. When a large number is to be used, voltage drop in the lines and across contact points would become excessive. One solution is the use of normally-open switches in parallel to short out a relay coil and stop the machine. A protective resistor is necessary to prevent a direct line-to-line short when stop contacts are closed. The system may be used with both ac and dc

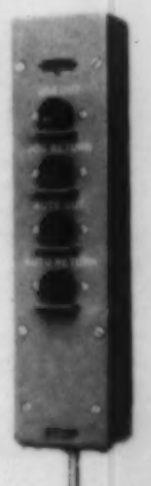


Fig. 6—Right—For safety's sake this pendant control station uses a lever-operated stop switch. No hunting is required to determine which button to push. Raised ribs on the enclosure cover prevent accidental operation of the four pushbuttons

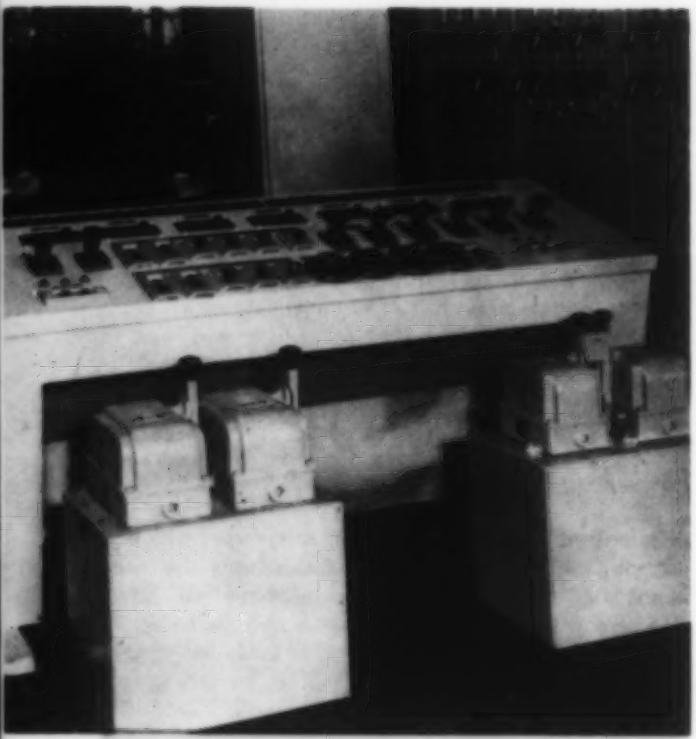
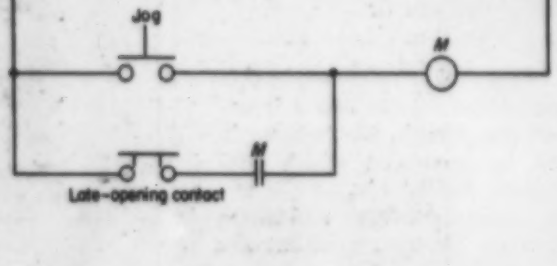


Fig. 7—Above—Control desk for a four-high reversing roughing mill has all switch functions plainly marked. Indicator lights are also used to show the operator what functions have been selected and are being controlled

Fig. 8—Below—Protection of contactors and motors from the ill effects of "teasing" or rapid jogging is provided by this "anti-tease" circuit. A pushbutton is used which has one standard normally-open contact and one long-wipe or late-opening normally-open contact. When the button is pushed, coil *M* closes contact *M* and maintains itself through the late opening contact. Releasing the button partially will not allow the contactor to drop out because the late opening contacts will not open until the button is almost fully released



smallest size and weight, *Figs*. 1, 2.

In an evaluation of required size, relative importance of the following factors should be considered.

1. Front of panel area
2. Rear of panel area
3. Rear of panel depth

Rotary switches tend to grow in depth with no increase in front-of-panel or rear-of-panel area requirement as complexity increases, *Fig*. 3. Multiple-pushbutton switches require more front and rear-of-panel area, but do not increase in depth as complexity grows. Lever-operated switches may increase in rear-of-panel area and/or depth as more contacts are added; front-of-panel area requirement is constant.

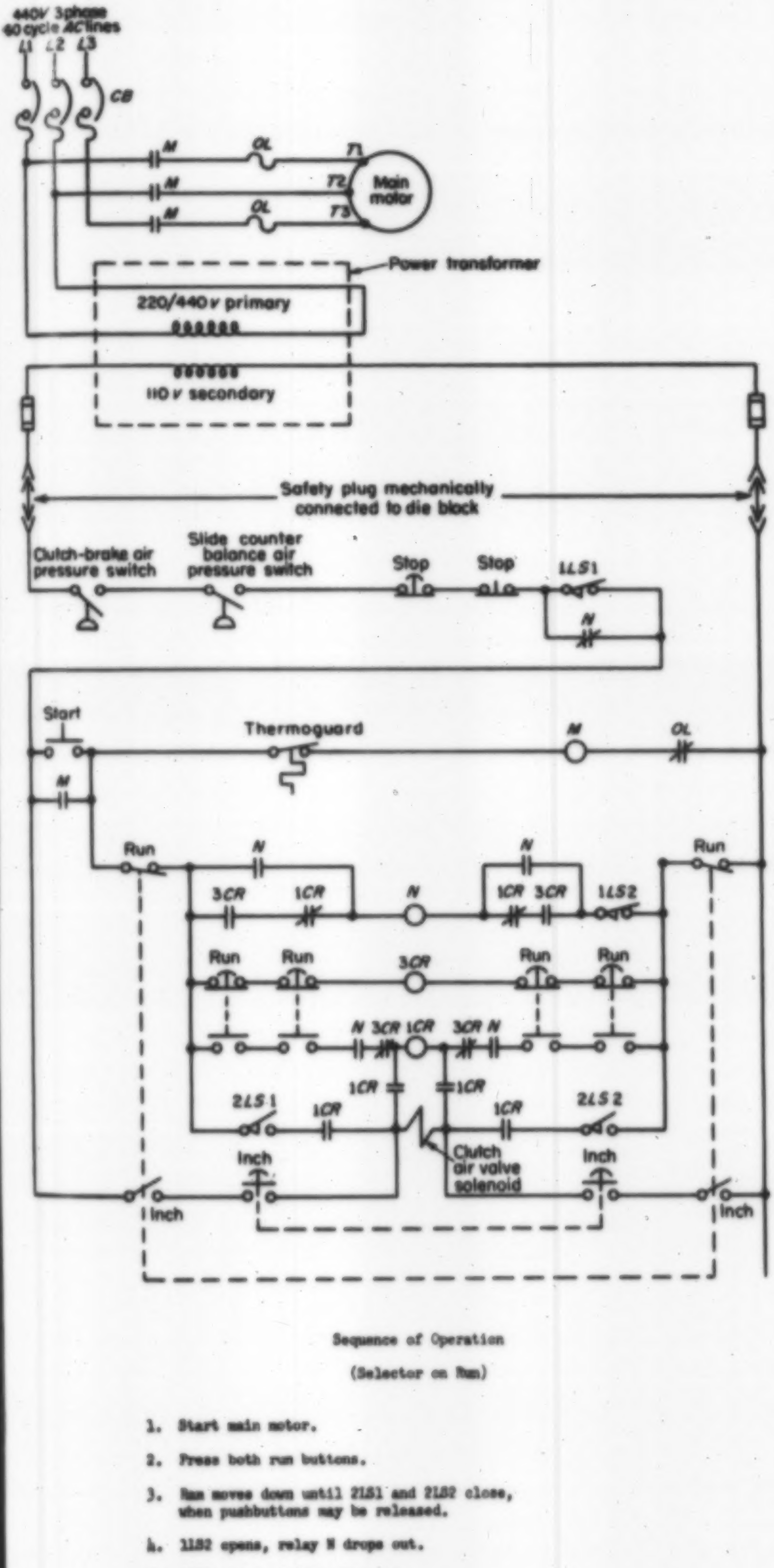
Cost: First cost of the switch should be weighed against other factors which may affect the assembled cost. Mounting requirements and type of terminals available are two factors which can influence installed cost. Size, of course, may also play a part, since both panel size, enclosure size, and the costs associated with these items, may vary with switch size.

Operating Conditions: Temperature, humidity, altitude, vibration, shock and other similar conditions may have profound effects upon switch performance. As would be expected, switches designed to operate under unfavorable conditions will usually cost more than those designed for less arduous duty.

For hazardous locations, switch enclosures of types meeting various NEMA standards are available for industrial pushbuttons as well as for drum switches. Toggle switches and toggle lever-actuated snap-action switches provide protection for moving parts and contact points since they are built in cases which are sealed in greater or lesser degree.

Required Life: Life requirements of switches may vary tremendously. In some applications a switch might operate twice a day in a machine with an estimated useful life of only a few years. At

Fig. 9—In large punch presses such as these, it is imperative that safe circuit interlocking be used to protect the operator from serious physical injury. Pushbuttons are physically located on the front of the machine so that the operator must use both hands to operate them. Additionally, limit switches stop the press if the operator removes either hand before the stroke has progressed to a point where the operator cannot get his hands between the dies. Various other safety features are also incorporated into the control unit. These are brought out by the diagram and accompanying explanation


440V 3phase
60 cycle AC lines
L1 L2 L3
CB
M
OL
T1
T2
T3
Main motor
Power transformer
220/440v primary
110v secondary
Safety plug mechanically connected to die block
Clutch-brake air pressure switch
Slide counter balance air pressure switch
Stop
Stop
1LS1
N
Start
Thermoguard
M
OL
M
Run
N
3CR
1CR
N
1CR
3CR
1LS2
Run
Run
Run
3CR
Run
Run
N 3CR 1CR
3CR N
1CR
1CR
2LS1
1CR
1CR
2LS2
Clutch air valve solenoid
Inch
Inch
Inch
Inch

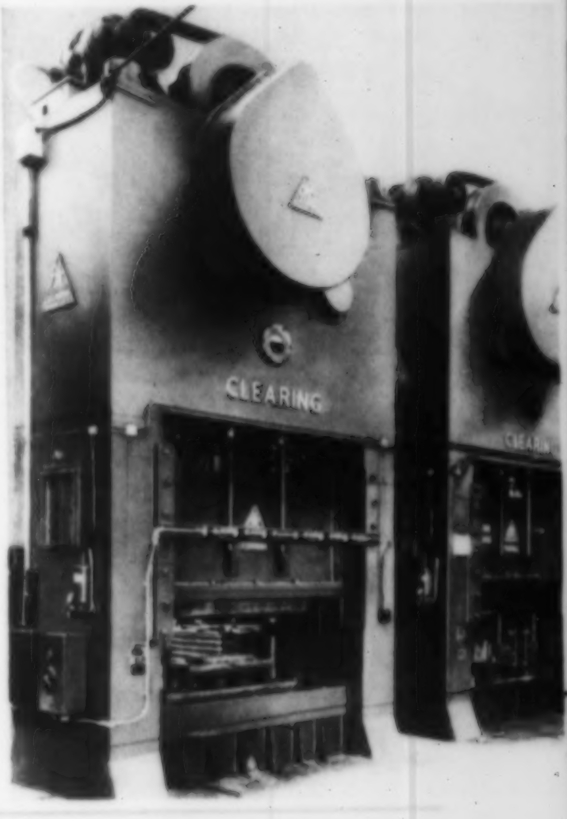
Sequence of Operation

(Selector on Run)

1. Start main motor.
2. Press both run buttons.
3. Ram moves down until 2LS1 and 2LS2 close, when pushbuttons may be released.
4. 1LS2 opens, relay N drops out.
5. 1LS1 opens, nothing happens.
6. 1LS1 and 1LS2 re-close.
7. 2LS1 and 2LS2 re-open to de-energize 1CR and solenoid and stop press.
8. Relay N picks up, if both pushbuttons have been released. Cycle complete, control ready for next operation.
9. If both pushbuttons have not been released, relay N stays dropped out, and press cannot repeat.

Failsafe Control Circuit Functions

Failure	Result
1. Loss of air pressure.	1. Entire control circuit de-energized. Press stops. Motor must be re-started and run PB operated after air pressure is restored.
2. Loss of power.	2. Press stops. Motor must be re-started and run PB operated after power restored.
3. Relay N fails to pick up.	3. Relay 1CR and solenoid cannot be energized. Press stops or cannot be restarted.
4. Relay N fails to drop out.	4. 1LS1 opens to de-energize entire control circuit. Main motor and press stop.
5. Relay N fails to drop out and operator keeps hands on run buttons.	5. Same as case 4.
6. Relay 3CR fails to pick up.	6. The pickup circuit for relay N is open. The next cycle is prevented.
7. Relay 3CR fails to drop out.	7. Pickup circuit for 1CR and solenoid open, press cannot be started.
8. Dummy bypass plug inserted in run receptacle by mistake.	8. Relay 3CR picked up. Protection same as case 7.
9. Relay 1CR fails to pick up.	9. Solenoid cannot be energized. Press cannot be started.
10. Relay 1CR fails to drop out.	10. Solenoid de-energized when 2LS1 and 2LS2 open and press stops. Pickup circuit to N open and new cycle cannot be obtained.
11. Relays 1CR and N both fail to drop out on the same stroke of the press.	11. 1LS1 opens to de-energize entire control circuit. Main motor and press stop. Pickup circuit to N relay also open. Next cycle prevented.
12. Relays 1CR and N both fail to drop out on the same stroke of the press and operators keep hands on run buttons.	12. Same as case 11.


CLEARING
CLEARING

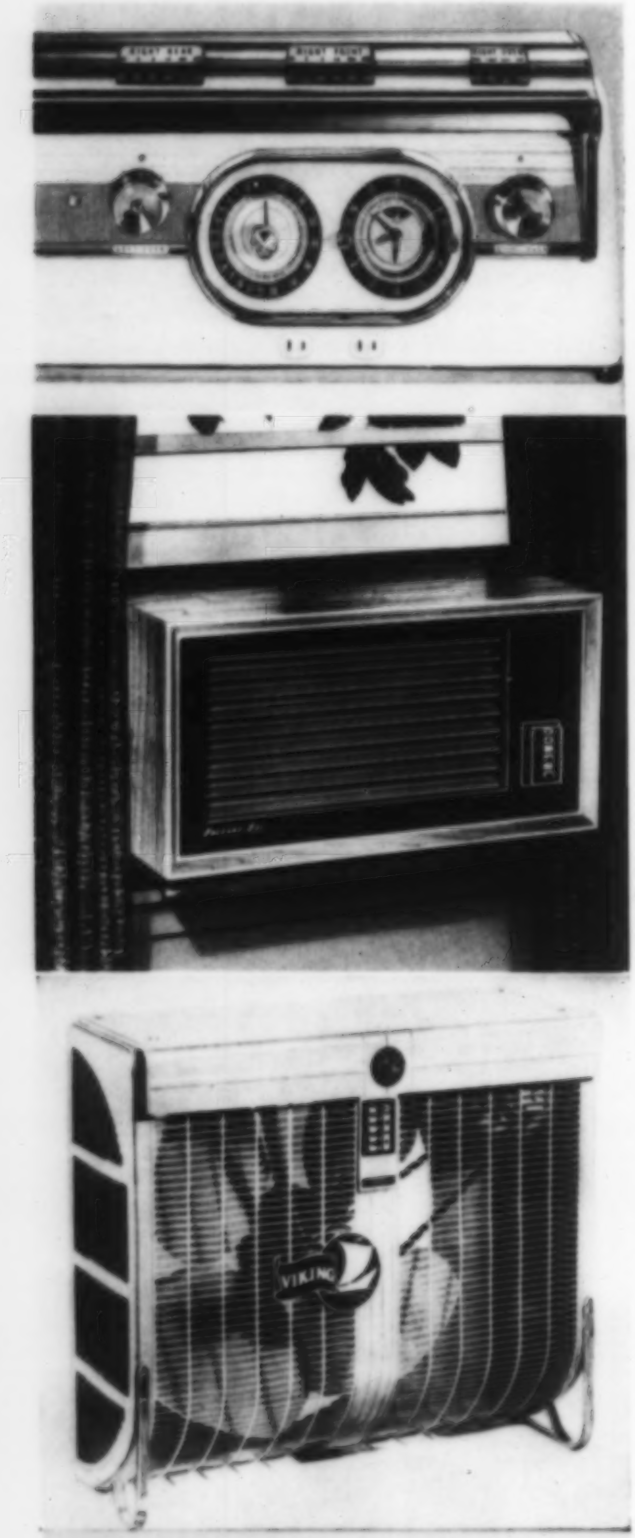


Fig. 10—Multiple-pushbutton switches fulfill requirements for appearance as well as other essential considerations for use in consumer products such as fans, air conditioners and stoves

Fig. 11—A shaft extension through the back of this rotary switch controls vanes which control intake air. Bead chain from the hub on the switch shaft to the vanes can be seen. This eliminates the necessity for another control on the panel of this air conditioner

the opposite extreme, a switch might be required to operate hundreds of times a day in a machine having an expected useful life of 30 years. Switches designed for either of these specific conditions are probably not obtainable. However, switch construction does vary for such reasons. Designers should ascertain that expected life of a switch is compatible with the life requirement or as nearly so as possible.

Operator Convenience: Two primary considerations in the matter of operator convenience are ease of operation of individual switches and overall complexity of a control panel when several switches must be used. Since the two do not necessarily go hand in hand, a compromise may be necessary.

When lever, rotary and pushbutton switches are compared on a basis of operator convenience, individual lever or push switches may be more convenient to actuate. However, as controls become more complex, pushbuttons or levers must be added at a much higher rate than would be necessary if rotary switches were used, *Fig.* 4.

Operator skill, as well as the circumstances under which switches are to be operated, are also of great importance. In some instances convenience and ease of operation may actually mean the difference between life or death, personal injury or destruction of a valuable piece of equipment, *Figs.* 5 and 6.

When a switch is used to control motion, there are certain natural directions of switch movement which correspond to both speed and direction of the motion being controlled. Machines should be designed so that switching movements conform to these natural human instincts or reactions when possible.

For lever-operated switches, such as toggle switches, experiment has shown that natural procedure is to move the lever up to turn the switch *on*, initiate action or increase speed. Rotary switches should be installed so that clockwise motion turns the switch *on,* starts the motor or increases speed. Push or pull switches should be arranged so that pushing turns them on, starts motion or increases speed. Construction of many pushbutton switches is such that this is not always possible, of course. Additionally, such an arrangement might not always be consistent with safe practice.

When linear motion which is observed by an operator is involved, motion of a switch lever, knob or button should parallel the motion involved. For example, if a hoist were to be controlled by push-buttons, the *up* button should be placed above the *down* button. If a toggle switch were to be used for the same application upward movement of the hook should be initiated by moving the switch lever upward.

Safety: When a switch of proper electrical capacity and suited for particular operating conditions—including hazardous atmospheres—has been chosen, safety requirements from the electrical standpoint have been fulfilled. However, the designer still has the responsibility of producing a safe device by choosing, positioning and arranging switches to prevent operator confusion and error, *Fig.* 7. Another safety consideration is the prevention of inadvertent switch operation due to accidental contact by the operator, *Fig.* 6.

Proper mechanical or electrical safeguards should be provided to protect both operator and machine from the consequences of incorrect switch manipulation, *Figs.* 8 and 9. The fellow who wants to find out what happens when *forward* and *reverse* buttons are pushed simultaneously will probably be around for quite a while. Certain switches prevent this sort of action by their very nature or by mechanical interlocking.

Appearance: Switch selection may affect appearance in different ways. First, individual types of switches and the associated operating knob, handle or button in themselves may tend to harmonize with certain surroundings but seem out of place in others, *Fig.* 10. For example, toggle switches with their coldly functional protruding handles are not frequently used on consumer products. In other applications, a toggle switch might be preferred to either a rotary or push type for just this reason.

Appearance is also affected by the number of switches on a panel. Again what is good and what is bad appearancewise may vary. For a certain product, it may behoove the designer to choose switches so that the fewest number possible may be used to keep the control panel as simple and unobtrusive as possible, *Fig.* 11. In another instance it may seem expedient to emphasize the control panel and use enough switches to convey the impression that here is a highly complex piece of technical apparatus.

ACKNOWLEDGMENT

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Allen-Bradley Co.	Milwaukee 4, Wis.
Allis-Chalmers Mfg. Co.	Milwaukee 1, Wis.
Ark-Les Switch Corp.	Watertown, Mass.
Arrow-Hart & Hegeman Electric Co.	Hartford 6, Conn.
Automatic Electric Co.	Chicago 7, Ill.
Barkelew Electric Mfg. Co.	Middletown, O.
Carling Electric Inc.	West Hartford 10, Conn.
Carter Parts Co.	Chicago 10, Ill.
Centralab Div., Globe-Union Inc.	Milwaukee 1, Wis.
Control Products Inc.	Harrison, N. J.
Cutler-Hammer Inc.	Milwaukee 1, Wis.
Daven Co.	Newark 4, N. J.
Electro-Snap Switch & Mfg. Co.	Chicago 24, Ill.
Electro Switch Corp.	Weymouth, Mass.
Federal Anti-Capacity Switch Corp.	Buffalo 8, N. Y.
Furnas Electric Co.	Batavia, Ill.
General Control Co.	Boston 34, Mass.
General Electric Co.	Schenectady 5, N. Y.
P. R. Mallory & Co. Inc.	Indianapolis 6, Ind.
Micro Switch Div., Minneapolis-Honeywell Regulator Co.	Freeport, Ill.
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Fig. 4	South Bend Lathe Works, South Bend, Indiana
Figs. 5, 6, 8, 9	Cutler-Hammer Inc., Milwaukee 1, Wis.
Fig. 7	Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.
Fig. 10	Ark-Les Switch Corp., Watertown, Mass., and Hotpoint Co., Chicago, Ill.
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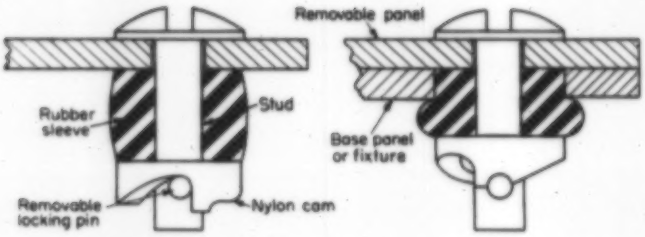
They Say . . .

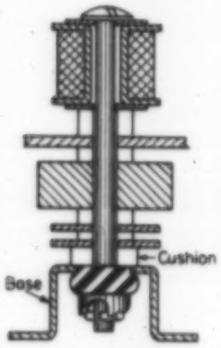
"The engineer is at the core of our nation's industrial growth. He originates and develops the many products of our economy. Scarcely can you name a man-made thing that people see, feel, hear, or taste but that comes into usage through the touch of an engineer. Yet, the very people who desire the benefits of all these things do not fully appreciate the importance of engineering to their well-being." — PAUL GARRETT, *vice president in charge of public relations, General Motors Corp.*

Panel Fasteners

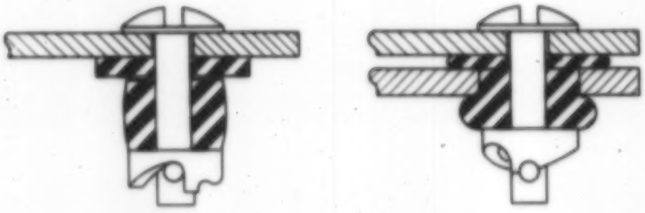
DESIGN DETAILS

Designed to provide a resilient panel joint, these fasteners are particularly suited to applications where demountability and cushioning of noise, rattles or vibration are important considerations. Locking action is obtained through a special rubber sleeve which expands laterally when compressed, acting to "float" and seal the panel assembly on a rubber suspension. In addition, the elastic mounting serves to compensate for slight alignment inaccuracies in mounting. Produced by the General Tire and Rubber Co., the fasteners are available in several types and sizes and can be used with glass, ceramic, and plastic panels as well as the customary metal types. A half turn of the stud engages or releases the fastener which locks inside a hole in the base panel and requires no auxiliary components for operation. Typical applications are shown in the accompanying illustrations.

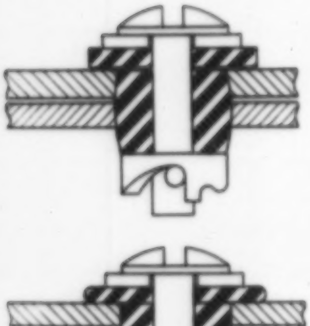




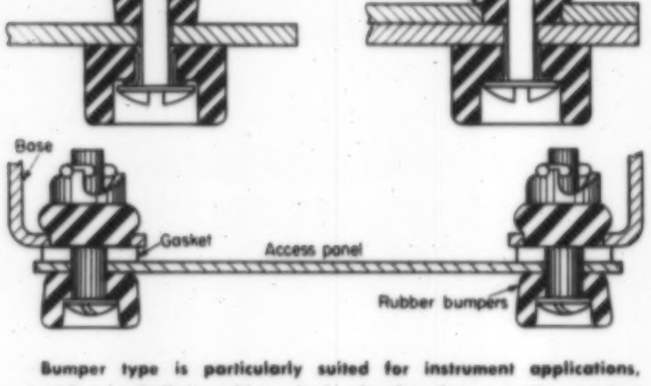
Flush type is suitable for panel-to-panel mounting or for use as a latch in rack, chassis or cabinet installations. Fastener is permanently attached to removable panel and will compensate mounting misalignment. Special type with long stud and spacers permits cushioned mounting of multiple components or panels with a single fastener, or can be employed where base is at a distance from the removable panel position.



Cushion type eliminates contact between panel and base fixture and provides floating rubber suspension. It is particularly useful for office machines or other similar inside panel installations where effective sound insulation is necessary. When a gasket is employed instead of the cushion washer, the fastener acts to position and lock the gasket in place, offering possibilities as a resilient door latch.



Button type is a "noncaptive" modification of flush type, not requiring attachment to the removable panel. Design is primarily suited for panel-to-panel joining or other similar flush fastener applications.



Bumper type is particularly suited for instrument applications, providing a built-in rubber shock absorber for protection against sudden jars or impacts at the base mounting. On access panel assemblies the fastener can also be utilized to position and lock a gasket in place as shown.

Practical solutions for design problems with standard components

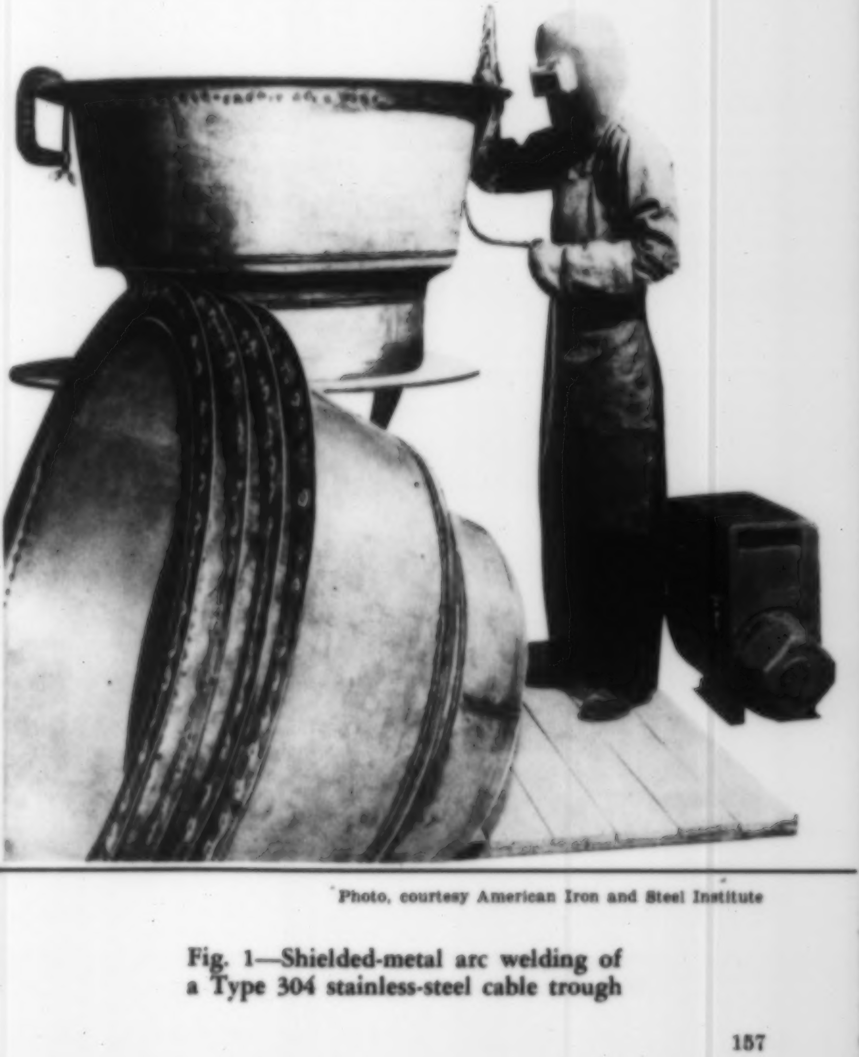
Weldability of Stainless Steel

A design guide to alloy selection, electrode and rod specification, and heat-treatment procedures

By Helmut Thielsch
Metallurgical Engineer
Grinnell Co. Inc.
Providence, R. I.

ALMOST all of the commercial stainless - steel grades are readily weldable by the various welding processes in commercial use. Among these are shielded-metal arc welding, inert-gas tungsten-electrode or consumable-electrode welding, submerged-arc welding, resistance welding, and oxyacetylene welding.* Although shielded-metal arc welding with covered electrodes, *Fig.* 1, is most used, the inert-gas tungsten arc, *Fig.* 2, and consumable-electrode, *Fig.* 3, processes are being increasingly used.

At least fifty different stainless-steel grades are produced commercially. About half of these are recognized as standard grades by the American Iron and Steel Institute and the Alloy Casting Institute. Since many of these grades differ in their response to welding, the designer and engineer specifying materials should understand the welding characteristics of the major grades. Where failures



Photo, courtesy American Iron and Steel Institute

Fig. 1—Shielded-metal arc welding of a Type 304 stainless-steel cable trough

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*For a review of these processes see: H. Thielsch—*Welding Procedures and Procedures Employed in Joining Stainless Steels*, Bulletin No. 13, Welding Research Council, 29 W. 39th St., New York.

have occurred, they can generally be ascribed to selection of incorrect base metal and electrode or welding-rod materials, and specification of incorrect welding procedures. Characteristics of the major types of stainless steels are reviewed briefly in *Table* 1, with particular attention to those characteristics affecting weldability.

As a general rule, the austenitic stainless steels are more readily and satisfactorily welded than the martensitic or ferritic chromium stainless steels. When properly made, welds in the austenitic stainless grades are strong, ductile and tough, even at low temperatures. They do not require preheat and postheat treatment to improve their mechanical properties. Almost all of the martensitic and ferritic chromium stainless steels are best welded when suitable preheat and postheat treatments are employed.

Welding Austenitic Stainless Steels

The common commercial wrought and cast chromium-nickel stainless steels and their welding characteristics are listed in *Tables* 2 and 3, respectively.

Carbide Precipitation: When the common austenitic stainless steels are exposed, during fabrication or in service, in the temperature range between 900 and 1500 F, the carbon tends to diffuse to the grain boundaries and combine with chromium to form chromium-carbide particles. This process, known as "inter-granular carbide precipitation," is illustrated in *Fig*. 4. A stainless steel in which it has occurred usually is described as "sensitized" by the exposure in the critical 900 to 1500 F sensitizing temperature range. Precipitation of these chromium-carbide particles at the grain boundaries reduces the resistance of the stainless steel to certain corrosive solutions. Since the corrosive attack occurs preferentially at the grain boundaries, it is generally known as "intergranular corrosion."

Severity of the effect of intergranular carbide precipitation primarily depends upon carbon content of the steel, the temperature, and the length of time it is held in the critical temperature range. Rate of precipitation is greatest at about 1200 F. When it occurs in the grain boundaries adjacent to a weld in that part of the heat-affected zone heated to temperatures between 900 and 1500 F, it is often referred to as "weld decay."

Types 301 and 302 stainless steels which contain 0.15 per cent max carbon are more susceptible to intergranular carbide precipitation than Types 304 and 308 which contain less than 0.08 per cent carbon. Rate of intergranular carbide precipitation is slightly retarded by a higher chromium and/or molybdenum content as in the Type 310, 309 or 316 grades. Intergranular corrosion may be prevented by the addition of columbium or columbium-tantalum (Types 347, 348, 318) or titanium (Type 321), a practice which is known as "stabilization." Intergranular corrosion may also be prevented by a suitable annealing heat treatment between about 1850 and 2050 F and quenching in water or a water spray following the final fabricating operation. If carbon content is limited to 0.03 per cent max, time for carbide precipitation can be lengthened and the amount diminished so that all normal welding operations may be carried out without deleterious effects. Stainless steels with 0.03 per cent max carbon content are referred to as extra-low-carbon grades.

Intergranular carbide precipitation resulting

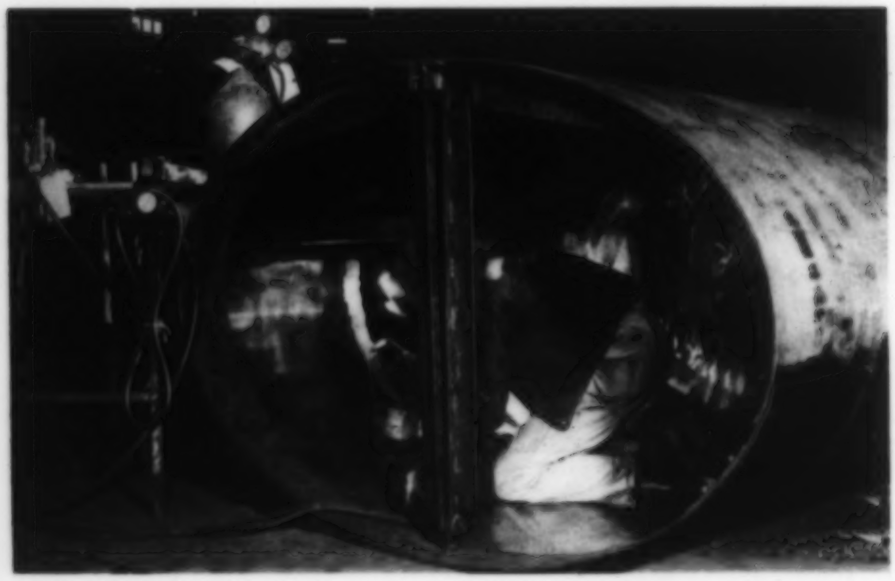

Fig. 2—Inert-gas tungsten-arc welding of Type 304 stainless-steel milk tank

Photo, courtesy American Iron and Steel Institute

Table 1

Commercial Stainless Steels

. . . characteristics affecting weldability

TWO major groups of stainless steels are produced commercially. One group contains chromium as its principal alloying element in quantities ranging from approximately 11 to 30 per cent. Alloys in the second group also contain a high percentage of chromium, varying between about 18 and 35 per cent, and in addition, contain between 6 and 36 per cent nickel. One of the primary differences between these so-called chromium grades and the chromium-nickel grades is in their metallurgical structure. The *chromium* stainless steels have either a martensitic hardenable or a ferritic nonhardenable structure. The *chromium-nickel* stainless steels have an essentially austenitic (nonhardenable) type of structure.

Each of these structures will give the stainless steel certain basic characteristic properties, which may vary widely. Ordinarily, the *austenitic* structure is strong, ductile, tough (even at low temperatures) and nonmagnetic; the *martensitic* structure is hard, brittle and magnetic, and gives the steel a high elastic limit; and the *ferritic* structure is soft, ductile and magnetic. Another important difference is that the primarily austenitic chromium-nickel stainless steels are characterized by a high thermal expansion, about 60 per cent greater than that of mild steel, whereas the martensitic and ferritic chromium stainless steels have a coefficient of expansion about 10 per cent less than that of mild steel. These expansion characteristics have to be considered in design and fabrication operations. For example, in welding, the high coefficient of expansion of the austenitic stainless steels may cause serious distortion, unless proper fixturing set-ups have been designed, and welding procedures which minimize distortion are followed. Excessive shrinkage may also reduce the final dimensions of the weld assembly to below an acceptable minimum. For example, in piping fabricated to exact dimensions, proper allowance for shrinkage has to be made in design.

Austenitic Chromium-Nickel Stainless Steels: The austenitic structure is not changed significantly by heat treatment. Thus, the majority of commercial austenitic stainless steel alloys available can be hardened only by cold working. The only exceptions are a few special so-called age-hardening grades usually alloyed with aluminum or copper. Because of the relatively small quantities in which the age-hardening grades are produced, they are not recognized by the American Iron and Steel Institute and the Alloy Casting Institute.

Chromium Stainless Steels: The chromium stainless steels (also called the *straight* chromium stainless steels) are generally separated into two further subclassifications: (1) the martensitic stainless steels and (2) the ferritic stainless steels.

MARTENSITIC OR HARDENABLE STAINLESS STEELS usually contain up to about 15 per cent chromium. Although these grades may be made ferritic by a final heat treatment between 1200 and 1400 F, they are primarily martensitic when cooled in air or when quenched into a liquid medium from temperatures above 1500 F. Maximum hardening in most of these grades is obtained by cooling from temperatures above 1750 F to room temperature. These steels, therefore, might be compared in their response to hardening and tempering to the ordinary hardenable carbon and alloy steels with slight temperature modifications.

FERRITIC STAINLESS STEELS usually contain between 10 and 30 per cent chromium. Heating and cooling produce no significant structural changes in these steels so that they remain essentially ferritic at all temperatures. These steels, therefore, can be hardened only by cold working, except for slight age-hardening characteristics shown by certain specially alloyed types.

Between 14 and 18 per cent chromium, the separation between the martensitic and ferritic stainless steel classifications is approximate and depends upon the composition of the particular stainless grade, primarily the carbon content. Thus, a high carbon content such as in the cutlery steel, Type 440, results in a hard martensitic structure. With a lower carbon content, this steel would be primarily ferritic, as in Type 430. The addition of aluminum also tends to make the steel ferritic even at a chromium content of 11.5 to 14.5 per cent, as in Type 405 which contains 0.10 to 0.30 per cent aluminum. On the other hand, 1 to 3 per cent nickel makes these steels essentially martensitic, as in Type 431, which contains 15.0 to 17.0 per cent chromium and up to 2.5 per cent nickel.

from welding or heating operations generally will not impair the mechanical properties of the steel.

Since welding exposes the stainless steel for only a relatively brief period in the sensitizing temperature range, the amount of intergranular carbide precipitation after welding is less than it would be after an extended service exposure at these elevated temperatures.

Fig. 3—Inert-gas consumable-electrode welding of Type 316 stainless-steel jet-engine parts

Photo, courtesy American Iron and Steel Institute

Unless the stainless steel is subsequently exposed to active corrosive solutions, the presence of a slight amount of precipitated carbides usually does not affect the life of the equipment. Thus, in mildly corrosive environments, as in dairy machinery, kitchen and cafeteria equipment, architectural decorative work and heat-resisting parts, welded structures made of stainless Types 301 and 302 generally will give entirely satisfactory service. Exceptions to this rule are occasionally found in heavily industrialized areas containing chemical plants where some corrosive attack adjacent to the weld deposit has sometimes been noted in these stainless-steel grades.

In many other mildly corrosive applications the 0.08 per cent max carbon Types 304, 308, 309S and 310S, 316 and 317, may be completely satisfactory in the as-welded condition. In these grades, intergranular carbide precipitation in the heat affected zone generally becomes appreciable only when the cooling time through the 1500 to 900 F temperature range exceeds approximately 1 to 1½ minutes.

When these nonstabilized grades are being welded, and when the service environment requires the absence of intergranular chromium-carbide precipitation in the steel, special precautions should be taken to allow the weldment to cool as rapidly as possible. This is generally accomplished by: (1) use of small-diameter electrodes, (2) low welding current, (3) deposition of the filler metal with

Table 2—Welding Recommendations for Wrought Austenitic Stainless-Steel Grades

AISI Designation	Popular Designation[1]	Chemical Composition (per cent) C	Cr	Ni	Others[2]	Recommended Electrode or Welding Rod[3]
301	17-7	0.15 max	16-18	6-8	....	E, ER308
302	18-8	0.15 max	17-19	8-10	....	E, ER308
302B	18-8 Si	0.15 max	17-19	8-10	2.0-3.0 Si	E, ER308
303	18-8FM	0.15 max	17-19	8-10	0.07 min P, S, Se; 0.60 max Zr, Mo	E, ER308[4]
304	19-9	0.08 max	18-20	8-12	....	E, ER308
304L	19-9 (extra-low carbon)	0.03 max	18-20	8-12	....	E, ER309L or E, ER347
305	18-10	0.12 max	17-19	10-13	....	E, ER308
308	20-10	0.08 max	19-21	10-12	....	E, ER308
309	25-12	0.20 max	22-24	12-15	....	E, ER309
309S	25-12 (low carbon)	0.08 max	22-24	12-15	....	E, ER309
309Cb[5]	25-12 Cb	0.20 max	22-24	12-15	Cb=10×C min	E309Cb
310	25-20	0.25 max	24-26	19-22	....	E, ER310
310S	25-20 (low carbon)	0.08 max	24-26	19-22	....	E, ER310
310Cb[5]	25-20 Cb	0.25 max	24-26	19-22	Cb=10×C min	E, ER310Cb
310Mo[5]	25-20 Mo	0.25 max	24-26	19-22	2.0-3.0 Mo	E, ER310Mo
314	25-20 Si	0.25 max	23-26	19-22	1.5-3.0 Si	
316	18-12 Mo	0.08 max	16-18	10-14	2.0-3.0 Mo	E, ER316
316L	18-12 Mo (extra-low carbon)	0.03 max	16-18	10-14	2.0-3.0 Mo	E, ER316L or E318
317	19-13 Mo	0.08 max	18-20	11-15	3.0-4.0 Mo	E, ER317
318[5]	18-12 Mo Cb	0.10 max	18-20	10-14	2.0-3.0 Mo; Cb=10×C min	E318
321	18-8 Ti	0.08 max	17-19	9-12	Ti=5×C min	E, ER347
347	18-8 Cb	0.08 max	17-19	9-13	Cb-Ta=10×C min	E, ER347
348	18-8 Cb	0.08 max	17-19	9-13	Cb-Ta=10×C min; 0.10 max Ta	E, ER347

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1. The 17-7, 18-10, 19-9, 19-12 designations are also often described as 18-8.
2. Unless otherwise specified Mn is 2.00 max, Si is 1.00 max, P is 0.040 max and S is 0.030 max.
3. AWS and ASTM specifications. Characteristics of the

1. The 17-7, 18-10, 19-9, 19-12 designations are also often

will be summarized in a subsequent article. E means grade recognized by AWS-ASTM as covered electrode; ER as bare electrode and welding rod.

4. Electrodes with lime type coverings are preferred.
5. Presently not recognized by AISI.

a stringer-bead technique (no weaving), (4) use of chill bars in the fixtures, and/or (5) immediate application of an air blast or a water quench or spray following the welding operation.

When the necessary rapid cooling rates cannot be provided, or when the corrosive application is extremely severe, extra-low-carbon or stabilized stainless-steel grades and electrodes have to be used. With less than 0.03 per cent carbon available in the extra-low-carbon grades, intergranular carbide precipitation is usually prevented. Although extra-low-carbon stainless-steel electrodes are available commercially, the extra-low-carbon grades are often welded with Type 347 (18-8 Cb) electrodes. The extra-low-carbon grades generally are not recommended for parts which are exposed during service at temperatures above 800 F.

Equipment which is operated continuously or intermittently at temperatures above 800 F and then exposed to a corrosive environment is generally made of the stabilized stainless grades, Types 321, 347 or 348. Type 347 electrodes are generally recommended for welding all stabilized grades, because the titanium in the Type 321 grade tends to burn off and segregate during welding. The only major exceptions are the inert-gas welding processes where the gas shielding provided allows titanium recovery of 60 to 85 per cent from type 321 filler wires. Nevertheless, columbium-stabilized Type 347 filler wires are used for inert-gas welding of Type 321 as well as Type 347.

Although stabilized Type 347 electrodes or welding rods have sometimes been specified for welding the unstabilized grades, no advantage is gained by this practice. As a general rule the recommendations given in *Tables* 2 and 3 should be followed.

Preheat Treatments: The austenitic stainless steels should not be preheated prior to welding, since such a procedure reduces the rate of cooling of the weld deposit and the heat-affected zone. A decrease in the cooling rate may increase the amount of intergranular carbide precipitation alongside the weld and in some alloys may also promote cracking in the weld metal.

Annealing: If intergranular chromium carbides have been formed, they can be brought back into solution by heating the steels to a temperature between 1850 and 2050 F for about ½ to 1 hr per inch of thickness and following this so-called solution heat treatment by rapid cooling, as obtained by quenching in water or by a water spray. On thin sections, 1/16-inch or less in thickness, air cooling usually is sufficiently rapid. Temperatures in the upper part of the range mentioned should be used for molybdenum-bearing austenitic stainless steel (e.g., Type 316), and all other grades which have carbon content exceeding 0.10 per cent C and/or a higher chromium-nickel content (Types 309, 310 and the 15 Cr, 35 Ni cast stainless-steel grade HT). In many welded structures this quench annealing treatment is not practical since it may

Table 3—Welding Recommendations for Cast Austenitic Stainless Steel Grades

ACI Designation	Popular Designation	Chemical Composition (per cent)				Recommended Electrode or Welding Rod[2]
		C	Cr	Ni	Other[1]	
CE-30	25-10	0.30 max	26-30	8-11	....	E312
CF-8	19-9	0.08 max	18-21	8-11	....	E, ER308
CF-20	19-9	0.20 max	18-21	8-11	....	E, ER308
CF-8M	19-10 Mo	0.08 max	18-21	9-12	2.0-3.0 Mo, 1.50 max Si	E, ER316
CF-12M	19-10 Mo	0.12 max	18-21	9-12	2.0-3.0 Mo, 1.50 max Si	E, ER316
CF-8C	19-10 Cb	0.08 max	18-21	9-12	Cb=8×C min, 1.0 max	E, ER347
CF-16F	19-10 MoFM	0.16 max	18-21	9-12	1.5 max Mo, 0.20-0.35 Se, 0.17 max P	E, ER308[3]
CF-16Fa	19-10 MoFM	0.16 max	18-21	9-12	0.40-0.80 Mo, 0.20-0.40 S	E, ER308[3]
CG-12	22-12	0.12 max	20-23	10-13	....	E, ER309
CH-10	25-12	0.10 max	22-26	12-15	....	E, ER309
CH-20	25-12	0.20 max	22-26	12-15	....	E, ER309
CK-20	25-20	0.20 max	23-27	19-22	....	E, ER310
CN-7M-Cu	.....	0.07 max	18-22	21-31	Cu, Mo, Si[4]	Special electrode
HC	28-4	0.50 max	26-30	4 max	1.00 max Mn, 0.5 max Mo[5]	329
HD	28-7	0.50 max	26-30	4-7	0.5 max Mo[5]	E, ER312
HE	28-10	0.20-0.50	26-30	8-11	2.00 max Mn, 0.5 max Mo[5]	E, ER312
HF	20-10	0.20-0.40	18-23	8-12	2.00 max Mn, 0.5 max Mo[5]	E, ER308
HH	27-12	0.20-0.50	24-48	11-14	2.00 max Mn, 0.5 max Mo, 0.2 max N_2[5]	E, ER309
HI	28-16	0.20-0.50	26-30	14-18	2.00 max Mn, 0.5 max Mo[5]	E, ER309
HK	25-20	0.20-0.60	24-28	18-22	2.00 max Mn, 3.00 max Si, 0.50 max Mo[5]	E, ER310
HL	30-20	0.20-0.60	28-32	18-22	2.00 max Mn, 3.00 max Si, 0.50 max Mo[5]	E, ER310
HN	22-25	0.20-0.50	19-23	23-27	2.00 max Mn, 2.00 max Si, 0.50 max Mo[5]	E, ER310
HT	15-35	0.35-0.75	13-17	33-37	2.00 max Mn, 2.50 max Si, 0.50 max Mo[5]	E330
HU	.....	0.35-0.75	17-21	37-41	2.00 max Mn, 2.50 max Si, 0.50 max Mo[5]	E330[6]

1. Unless otherwise specified Mn is 1.50 max, Si is 2.00 max, P and S are 0.04 max.
2. AWS and ASTM specifications. Characteristics of the commercial stainless-steel electrodes and welding rods will be summarized in a subsequent article. E means grade recognized by AWS-ASTM as covered electrode; ER as bare electrode and welding rod.
3. Electrodes with lime-type coverings are preferred.
4. There are several proprietary alloy compositions falling within the stated chromium and nickel ranges which contain varying amounts of silicon, molybdenum and copper. Such alloys are available from licensed producers only.
5. Molybdenum is not intentionally added.
6. 18 Cr, 38 Ni electrodes are also used.

result in serious distortion and buckling.

Stress Relieving: In austenitic stainless steels stress relieving at 1350 F generally is considered detrimental. The degree of harm varies from one grade to the other. Stress relieving the unstabilized grades may cause serious intergranular carbide precipitation which will considerably reduce corrosion resistance to many solutions. Undesirable metallurgical effects may also result in several of the grades, such as the formation of the sigma phase.

Because the detrimental effects produced by stress relieving often outweigh the advantages gained, the austenitic stainless steels should receive stress-relieving heat treatments only under certain conditions. For example, vessels to be in service where stress corrosion might be encountered may have to be stress relieved, although use of the treatment requires judgment.

Welding Martensitic Stainless Steels

The common commercial martensitic stainless steels and their welding characteristics are summarized in *Table* 4.

In the martensitic stainless steels, susceptibility to hardening is increased as chromium content decreases and as carbon content increases. Steels with high chromium and low carbon contents tend to approach the characteristics of the ferritic stainless steels. Thus, in the absence of other alloying elements a 13 per cent chromium stainless steel containing less than about 0.08 per cent carbon is often considered to be only "partially" martensitic. Grades with more than 0.08 per cent carbon would be considered to be fully martensitic.

Tendency of the martensitic weld metal and the heat-affected zone to be hard and brittle is often minimized by suitable preheat and postheat treatments. The best procedure varies somewhat with each grade of steel.

Fully Martensitic Grades: Without preheat treatments the highly hardenable, fully martensitic stainless-steel grades generally are susceptible to cracking in the martensitic weld deposit and in the heat-affected zone, particularly when heavy sections are being welded. Light sections of the lower-carbon grades may be an exception. For example, Type 410 in light sections up to ⅛-inch ordinarily exhibits good welding characteristics so that preheating provides little improvement and

Table 4—Welding Recommendations for Martensitic Stainless Steels

ACI or AISI Designation	Popular Designation	Chemical Composition (per cent)			Welding Recommendations		
		C	Cr	Others[1]	Recommended Electrode or Welding Rod[2]	Preheat Interpass Temperature	Post heat Treatment[3]
Wrought Stainless Steels (AISI)							
403	12 Cr	0.15 max	11.5-13.0	Turbine quality; 0.50 max Si	E, ER410	600-700 F	....
410	12 Cr	0.15 max	11.5-13.5	....	E, ER410 E, ER310 or E, ER309	600-700 F[8] 400-600 F	Highly recommended Recommended[4]
410 mod	12 Cr	0.08 max	11.5-13.5	....	E, ER410 E, ER310 or E, ER309	300-500 F[8] 300-500 F	Highly recommended Recommended
414	12 Cr, 2 Ni	0.15 max	11.5-13.5	1.25-2.50 Ni	E, ER410 E, ER310 or E, ER309	600-700 F 400-600 F	Highly recommended Highly recommended[5]
416	12 Cr-FM	0.15 max	12.0-14.0	0.07 min P, S, and Se; 0.60 max Zr and Mo	E, ER430 or E, ER410	600-700 F	Highly recommended[6]
420	13 Cr	Over 0.15	12.0-14.0	....	E, ER410 or E, ER430 E, ER310 or E, ER309	600-700 F 400-600 F	Highly recommended Recommended
431	16 Cr, 2 Ni	0.20 max	15.0-17.0	1.25-2.50 Ni	E, ER430 E, ER310 or E, ER309	600-700 F 400-600 F	Highly recommended Recommended
440A	17 Cr	0.06-0.75	16.0-18.0	0.75 max Mo	E, ER430 or 442	600-700 F	Required[7]
440B	17 Cr	0.75-0.95	16.0-18.0	0.75 max Mo	E, ER430 or 442	600-700 F	Required[7]
440C	17 Cr	0.95-1.20	16.0-18.0	0.75 max Mo	E, ER430 or 442	600-700 F	Required[7]
Cast Stainless Steels (ACI)							
CA-15	12 Cr	0.15 max	11.5-14.0	1 max Mn, Ni; 1.5 max Si	E, ER430 E, ER310 or E, ER309	600-700 F[8] 400-600 F	Highly recommended Recommended[4]
CA-40	13 Cr	0.20-0.40	11.5-14.0	1 max Mn, Ni; 1.5 max Si	E, ER410 or E, ER430 E, ER310 or E, ER309	600-700 F 400-600 F	Highly recommended Recommended

[1] Unless otherwise specified Mn and Si are 1.00 max, P is 0.40 max and S is 0.030 max.

[2] AWS and ASTM specifications. Characteristics of the commercial stainless-steel electrodes and welding rods will be summarized in a subsequent article. E means grade recognized by AWS-ASTM as covered electrode; ER as bare electrode and welding rod.

[3] 1300-1450 F for 1 hr per inch of thickness.

[4] When preheat treatments are not employed use small diameter electrodes.

[5] On thinner gages, postheat treatments may be omitted.

[6] Welding is not recommended.

[7] These steels generally are not recommended for welding. When welding or repair welding is necessary preheat and postheat treatments must be employed.

[8] Highly recommended where possible.

The Article and the Author

Helmut Thielsch is responsible for welding research and development, adoption of new welding techniques, and preparation of welding and fabricating specifications at the Grinnell Co.

From 1949 to 1952 he was associated with the Welding Research Council, where he prepared interpretive reports and recommendations pertaining to welding. As a member of various ASTM, AWS and other code-writing committees, he has kept in close contact with the latest techniques in welding and weldment fabrication. Earlier work included metallurgical experience with Lukens Steel Co., Black, Sivalls and Bryson, and Allis-Chalmers Mfg. Co.

A contributor to the forthcoming *ASME Handbook* on Processes, Mr. Thielsch has written some 40 papers and articles on various welding, metallurgical and engineering subjects.

The present article is actually the second of a comprehensive group on major design factors in welding. The first article appeared in the May issue of Machine Design under the title, "Wrought Carbon and Alloy Steel: Weldability."

Forthcoming articles will give important design information on such aspects of welding as weldability of cast steels; dissimilar-metal joints; electrodes and welding rods; properties of weldments; specifying testing and inspection procedures; and factors affecting welding costs.

Table 5—Welding Recommendations for Ferritic Stainless Steels

AISI or ACI Designation	Popular Designation	Chemical Composition (per cent)			Welding Recommendations		
		C	Cr	Other[1]	Recommended Electrode or Welding Rod[2]	Preheat and Interpass Temperature	Postheat Treatment[5]
Wrought Stainless Steels (AISI)							
405	12 Cr, Al	0.08 max	11.5-14.5	0.10-0.30 Al	E, ER430 E, ER310 or E, ER309	Not necessary Not necessary	Highly recommended Recommended
406	12 Cr, 4 Al	0.15 max	12.0-14.0	3.50-4.50 Al	[3]	....	....
430	16 Cr	0.12 max	14.0-18.0	....	E, ER430 E, ER310 or E, ER309	Not necessary Not necessary	Highly recommended Recommended
430F[4]	10 Cr-FM	0.12 max	14.0-18.0	0.07 min P, S, Se; 0.60 max Zr, Mo	E, ER430	Not necessary	Recommended [4]
442[6]	18 Cr	0.35 max	18.0-23.0	....	442 or 446 E, ER309 or E, ER310	Not necessary, but usually recommended between 300-400 F Same	Essential Highly recommended
446	27 Cr	0.20 max	23.0-27.0	0.25 max N_2	446 E, ER310 or E, ER309	300-400 F Not necessary	Essential Recommended
Cast Stainless Steels (ACI)							
CB-30	20 Cr	0.30 max	18.0-22.0	2.0 max Ni	442 E, ER309 or E, ER310	Not necessary, but usually recommended between 300-400 F Same	Essential Highly recommended
CC-50	27 Cr	0.50 max	26.0-30.0	4.0 max Ni	446 E, ER309 or E, ER310	300-400 F Not necessary	Essential Recommended
HC	27 Cr	0.50 max	26.0-30.0	2.0 max Si; 4.0 max Ni	446 E, ER309 or E, ER310	300-400 F Not necessary	Essential Recommended

1. Unless otherwise specified Mn and Si are 1.00 max, P is 0.040 max and S is 0.030 max.
2. AWS and ASTM specifications. Characteristics of the commercial stainless-steel electrodes and welding rods will be summarized in a subsequent article. E means grade recognized by AWS-ASTM as covered electrode; ER as bare electrode and welding rod.
3. Not recommended for welding. When repair welding is necessary use Type 310 electrodes of small diameter and low welding currents.
4. Welding is not recommended.
5. 1300-1450 F for 1 hr per inch of thickness.
6. Presently not recognized by AISI.

may be omitted.

Cracking may be minimized or avoided by preheating these steels to temperatures between 400 and 700 F, depending upon the hardening characteristics of the base metal and weld metal, and the intended service requirements. The preheat temperatures should be maintained during the welding operation.

A postheat treatment between 1300 and 1450 F should follow immediately upon completion of welding for 1 hour per inch of thickness (minimum treatment of 1 hour). The postheat-treated sections should be cooled in air. Under these conditions very ductile weldments may be obtained. In some cases, the postheat treatment may be done at any convenient time or may even be omitted and still result in completely satisfactory welds. Such procedures, however, should be specified only after consulting with a properly qualified and experienced welding engineer.

Partially Martensitic Grades: The presence of some ferrite in the otherwise martensitic structure decreases the hardness developed in the steel, as, for example, in the modified Type 410 grade (0.08 max C). This ferrite reduces cracking susceptibility. Nevertheless, cooling rates and interpass temperatures should be controlled. Preheat treatment between 300 and 500 F is generally advisable and should be followed by postheat treatment at 1300 to 1450 F. Only when welding thin sheet below about $\frac{1}{16}$-inch thickness may these preheat and postheat treatments be omitted.

Martensitic vs Austenitic Electrodes or Welding Rods: When commercial Type 410 electrodes or welding rods are used to weld the Type 410 stainless steels, a preheat temperature between 500 and 700 F is advisable unless the joint thickness is less than $\frac{1}{8}$-inch. When low-carbon (modified) Type 410 grades (0.08 max C) are welded with Type 410 electrodes, this preheat temperature may be reduced.

Welding with either Type 310 or 309 austenitic stainless-steel filler metals is preferred if a postheat treatment is not possible. Nevertheless, the use of Type 410 filler metals is far better from a metallurgical point of view.

Welding Ferritic Stainless Steels

Welding recommendations for the common commercial ferritic stainless steels are summarized in *Table* 5.

Since the ferritic stainless steels are not subject to air hardening, they are less susceptible to cracking in the welded section than the martensitic stainless steels. However, because these steels may become embrittled, their welding characteristics should be understood.

The chromium stainless steels which become fully ferritic at temperatures above 2100 F are generally susceptible to an embrittlement which is associated with solution of the carbide particles. This embrittlement is accompanied by severe grain growth. The embrittlement can be removed by annealing the steel for 1 hr between about 1300 and 1450 F followed by quenching or air cooling, even though the grain size remains coarse. Such a postheat treatment is particularly important in single-pass welding where, without this postheat treatment, the ferritic weld metal as well as part of the heat-affected zone would be extremely brittle, and would readily crack on subsequent deformation or bending operations at room temperature.

When postheat treatment is not possible, multipass welding with small-diameter electrodes, low current and stringer beads should be used to minimize this embrittlement. In these deposits the subsequent weld beads produce annealing effects in the earlier beads and reduce brittleness in the weld and heat-affected zone.

Ferritic vs Austenitic Electrodes or Welding Rods: Since Types 405, 430 and 442 tend to contain an average of about 50 to 70 per cent ferrite, the balance being martensite, suitable preheat and postheat treatments are usually required to prevent hardening.

In the welding of chromium stainless steels containing up to 23 per cent chromium, satisfactory results are generally obtained with electrodes and welding rods having compositions similar to the base metal. However, Type 309 austenitic stainless-steel electrodes and welding rods are also extensively used, although the trend is toward the use of the ferritic chromium stainless-steel electrodes listed in *Table* 5. Preheat treatments are preferred. A postheat treatment at 1300 to 1450 F is essential if ductility is important, unless service at temperatures above 1000 F produces a similar effect.

Chromium stainless steels containing more than 23 per cent chromium are preferably welded with Type 310 or 309 electrodes.

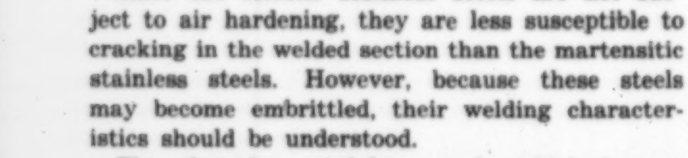

Fig. 4 — Intergranular carbide precipitation in "sensitized" Type 304 stainless steel

Design for Plating

Specifications and practices for electroplated coatings

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ELECTRODEPOSITS are applied for appearance, economy, wear resistance and corrosion resistance. Only one of these factors may be predominant in an application, but several or all usually apply.

In some cases the deposit may be used to protect the part from failure due to corrosion. For instance, unplated automobile trim would corrode to the point of falling to pieces. In other applications the plated surface greatly increases life due to wear resistance, such as a chromium-plated shaft.

But many times the electroplate is used for better appearance or sales appeal—the coating is applied to avoid unsightly staining, pitting or rusting. Life in these terms is limited by the thickness of the deposit, since the base metal will only be protected as long as the coating remains. Thus, life is controlled by the wear and corrosion resistance of the coating, which depend both on the type of plating metal used and its thickness.

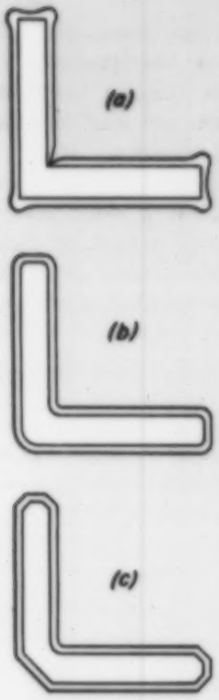

Fig. 1—Designs for plating corners

Table 1—Common Applications of Electrodeposited Metals

Coating Metal	Application
Cadmium	Corrosion resistance to moisture or salt air
Chromium	Appearance and wear resistance
Copper	Undercoat for nickel
Iron	Build-up of worn parts
Lead	Corrosion resistance to chemicals
Nickel	Appearance, corrosion resistance and wear
Silver	Appearance
Tin	Corrosion resistance, particularly on cans
Zinc	Corrosion resistance—outdoor exposure

Table 2—Minimum Thickness of Zinc and Cadmium Coatings on Steel

Coating Metal	ASTM Coating Type*	Thickness (in., min)	ASTM Standard
Zinc	G.S.	0.0010	A164–53
	L.S.	0.00050	
	R.S.	0.00015	
Cadmium	N.S.	0.00050	A165–53
	O.S.	0.00030	
	T.S.	0.00015	

*Arbitrary designations.

Type of Coating: Although applications for electrodeposits are endless, their common uses are shown in *Table* 1. A definite metal or combination of metals is often chosen on a basis of common practice. The alternative is to set up an expensive testing program to evaluate serviceability on the basis of wear or corrosion. After the type of coating and the thickness is decided, the specification is determined.

Coating Specifications: It is usually convenient and practical to use a specification, since it provides a common ground for testing and acceptance of the deposit. *Tables* 2 through 6 show the minimum thickness for various metallic coatings electrodeposited on steel, copper or zinc alloys.[1]

A specification can be merely a required minimum thickness shown on a print; it can be to a government or society specification; or it can be written in detail to define measuring and testing methods.

Of these three possibilities the first and last are probably most satisfactory. If the application is not critical, limits for minimum and maximum thickness are designated on the print. If the application is critical, methods of sampling, types of measurements, and definitions should be included in the specification. Merely to specify an ASTM number can lead to troubles in the interpretation of the test at a later date, with the result that production of a part or machine may be held up during some phase of inspection. Specifications should be decided upon by mutual agreement among the designer, the laboratory personnel and the production plating department.

Table 3—Minimum Thickness of Copper-Nickel-Chromium on Steel*

ASTM Coating Type†	Copper plus Nickel (in., min)	Final Nickel (in., min)	Chromium (in., min)
D.S.	0.0020	0.0010	0.000010
F.S.	0.0012	0.00060	0.000010
K.S.	0.00075	0.00040	0.000010
Q.S.	0.00040	0.00020	0.000010

*From ASTM standard A166-53T.
†Arbitrary designations.

Table 4—Minimum Thickness of Nickel-Chromium on Copper Alloys*

ASTM Coating Type†	Nickel (in., min)	Chromium (in., min)
F.C.	0.00050	0.000010
K.C.	0.00030	0.000010
Q.C.	0.00010	0.000010

*From ASTM standard B141-45.
†Arbitrary designations.

Variation in Deposit Thickness: The basic electroplating problem is one of obtaining the required thickness of metal on the desired areas. Difficulties usually encountered are either heavy plating on corners and edges or thin plating in holes and recesses. Because of this difficulty, *significant surfaces* are often defined.

"In general, significant surfaces are those surfaces that are visible and subject to wear or corrosion, or both. The designation of significant surfaces shall be agreed on by the manufacturer and the purchaser, and may be indicated on the drawings."[1]

Significant surfaces are defined to assure an adequate thickness of metal on the area that is likely to fail, either from corrosion or wear. If corrosion is a factor, then a minimum thickness may be required on all surfaces. If wear is a factor, it may even be desirable to deposit extra metal on the exposed area, such as done on the outside surface of the bowl of a teaspoon.

Plating Corners: The result of plating on sharp corners is shown in *Fig. 1a*. On the outside corner a heavy deposit is built up. This difficulty may be reduced by the use of "shadows" or "robbers" by the electroplater, but these methods mean extra expense in plating rack design. It is better to plate on a rounded corner; even a 1/64-inch chamfer will make considerable difference. The metal will still be heavier on the rounded corner than on flat areas. In some cases this is desirable, since the corner may be exposed to more wear than flat surfaces.

If an inside corner is square, nothing can be done by the plater to improve plating in the corner.

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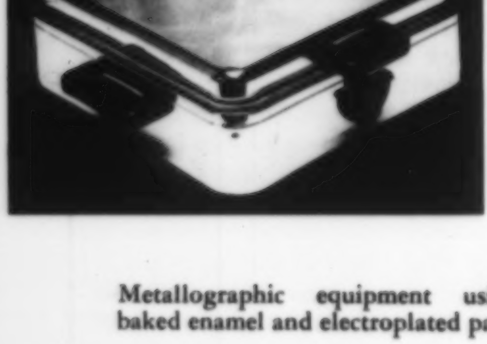
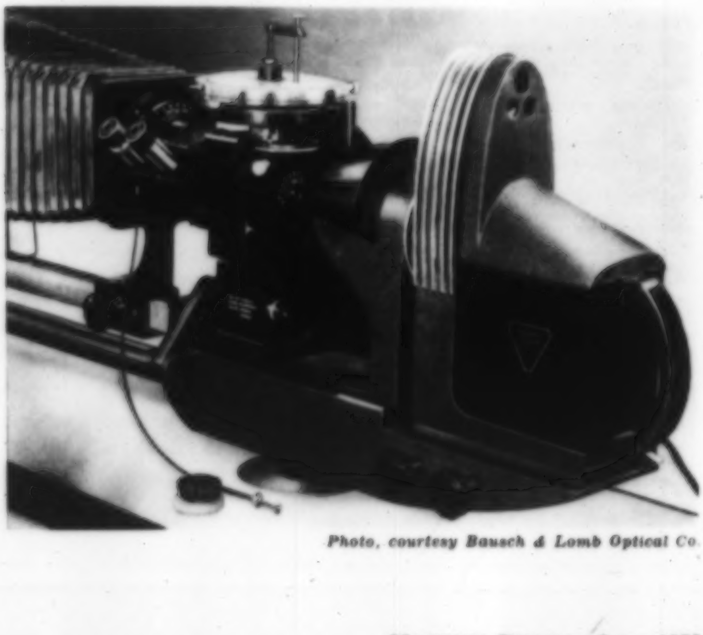
[1] References are tabulated at end of article.

Waffle iron plated with nickel and chromium

Photo, courtesy Sunbeam Corp.





Metallographic equipment using baked enamel and electroplated parts

Photo, courtesy Bausch & Lomb Optical Co.

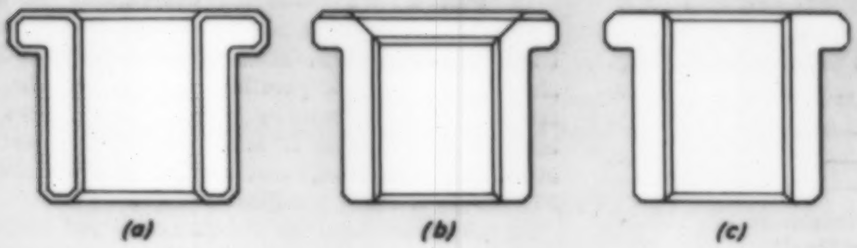
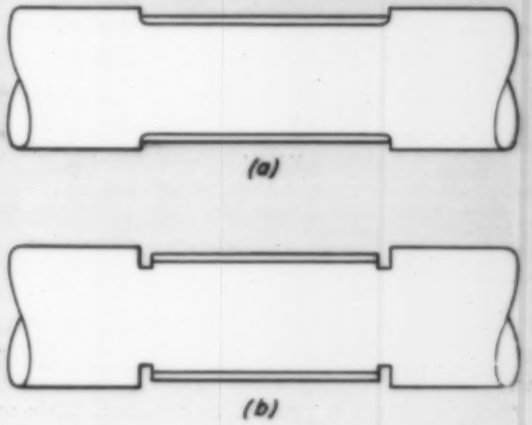


Fig. 2—Left — Design of plated cylindrical single-flanged bushings

Fig. 3—Below—Design of recessed shafts with plated bearing surfaces



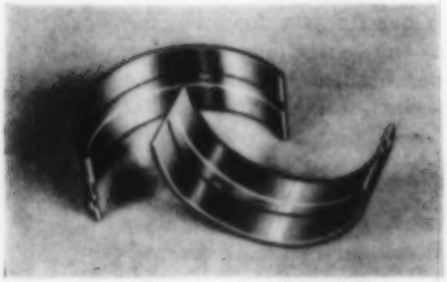
The only answer here is to provide a sufficient radius. A research study by the American Electroplaters' Society[2] indicates that a radius of 0.020-inch or greater is desirable to obtain plating on an inside corner.

The sketch in *Fig.* 1*b* shows how a more favorable metal distribution obtained by rounding of corners. A similar effect obtained by the use of an outside chamfer and an inside radius, *Fig.* 1*c*. If a chamfer or rounded corner is rough cut, it may also be necessary to remove burrs by a hand or mechanical operation to obtain good results.

If the part is an intricate stamping that presents areas difficult to plate, it may be possible to plate prior to forming. In fact, preplated flat stock is available as a cost-saving commercial material for such purposes. It is definitely more economical to plate flat stock on a continuous strip-plating line than to plate finished pieces on a plating rack.

Engineering Uses of Plating: In addition to the uses of plating for appearance, wear and corrosion resistance there are many engineering uses to be considered in the design of machine elements.

SELECTIVE CARBURIZING: Certain applications call for some areas of a part to be hard for wear resistance and other areas to be soft for subsequent machining or straightening after hardening. Copper plating, 0.005-inch thick, will effectively stop-off the area to remain soft in a carburizing or nitriding process.[3] Thickness of copper required depends on the base metal surface finish; with a good finish much thinner coatings are possible.[4] The copper is either (1) selectively plated on the surface to remain soft by the use of an organic stop-off applied to the part prior to plating or (2) the part is plated all over and the copper is machined away from the area to be hardened.


Photo, courtesy Johnson Bronze Co.

Sleeve bearings with precision tin plating 0.0005-inch thick on ID for bearing purposes and flash tin plating 0.00004-thick on OD for protective purposes

PLATING AS A LUBRICANT: For parts that are to be formed and require a protective coating, tin plating is economical. The tin will act as a lubricant during forming operations and reduce troubles with sticking and galling of dies. The same coating will have protective value during subsequent storage and use of the part. Thicknesses of 0.00002 to 0.00005-inch have been found useful for this purpose.

A similar application is the use of tin or silver

Table 5—Minimum Thickness of Copper-Nickel-Chromium on Zinc Alloys*

ASTM Coating Type†	Copper (in., min)	Copper plus Final Nickel (in., min)	Final Nickel (in., min)	Chromium (in., min)
F.Z.	0.00020	0.0012	0.00050	0.000010
K.Z.	0.00020	0.00075	0.00030	0.000010
Q.Z.	0.00020	0.00050	0.00030	0.000010

*From ASTM standard B142-53.
†Arbitrary designations.

0.0001 to 0.0002-inch thick as an antifret surface. If a part is subject to very slight motion at high pressures; such as the back of a sleeve bearing, a thin surface of these metals will prevent fretting.

SELECTIVE PLATING: In engineering applications, the plating is only required on specific surfaces. Offhand it may seem advantageous to plate all over to obtain a protective coating. This may be desirable, but can be expensive if a relatively heavy coating is to be machined after plating.

Table 6—Minimum Thickness of Copper-Lead on Steel*

ASTM Coating Type†	Copper (in., min)	Lead (in., min)
E.S.	....	0.0010
E.E.S.	0.000015	0.0010
M.S.	....	0.00050
M.M.S.	0.00015	0.00050
P.S.	....	0.00025
P.P.S.	0.000015	0.00025

*From ASTM standard B200-53T.
†Arbitrary designations.

In *Fig.* 2 are examples of various designs for plating a flanged sleeve bearing which is to be machined to size after plating. The method shown in *Fig.* 2*a* is possible, but it would be extremely difficult because plating would have to be done in a number of steps to preserve locating surfaces. Therefore, cost would be very high. *Fig.* 2*b* is a more practical design.

If the thrust load on the flange is not critical, it is much cheaper to plate only the ID as in *Fig.* 2*c*. The flange and other surfaces may be flash-plated after the part is finished or just prior to final boring. If a flash plating is applied, complications may be avoided if the same type of plating used for plating the ID is selected.

Chromium plating on a journal surface may be done as shown in *Fig.* 3. If the technique shown in *Fig.* 3*a* is used, it may be difficult to plate into the corner. This problem is easily solved by providing an undercut, *Fig.* 3*b*.

REFERENCES

1. *Specifications and Tests for Electrodeposited Metallic Coatings*, American Society for Testing Materials, Philadelphia, September, 1953.
2. *Plating*, Vol. 40, 1953, Page 900.
3. Burns and Schuh, *Protective Coatings for Metals*, Reinhold Publishing Co., 1939, Page 197.
4. J. S. Vanick and H. K. Herschman, *Trans. Am. Soc. Steel Treat.*, Vol. 4, 1923, Page 305.

CONTEMPORARY DESIGN

Refrigerator and Freezer Combined

AN UPRIGHT freezer and a refrigerator have been combined into a single 16-cubic foot cabinet and labelled the Foodorama. The two sections are divided by an insulated wall and each has its own door which opens from the center out. Measuring 60 inches high, 47¾ inches wide and 26½ inches deep, the cabinet has nearly 5 cubic feet of freezer space and more than 11 cubic feet of refrigerator space. A single compressor provides refrigeration for both compartments. Separate temperature controls are installed. Made by Kelvinator Div., American Motors Corp., the Foodorama is available in eight exterior colors in addition to white.

An equivalent energy method for determining

Dynamic Characteristics of Mechanisms

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ACCURATE determination of dynamic characteristics of mechanisms has become more important with the increasing demand for higher speeds and more efficient designs. Circuit breakers, computing mechanisms and other mechanical devices are examples of the types of products which may benefit by an accurate determination of velocities, accelerations and forces.

In general most mechanical systems may be divided into two basic groups:

1. Continuously operating systems in which one member rotates with constant or nearly constant angular velocity.
2. Limited-motion systems with arbitrarily imposed input and output force-displacement relationships.

In the first case analysis starts with the assumptions that one member rotates at constant angular velocity and that the power source, which may include a flywheel, produces the variable input required. Adequate theory and methods for solving problems of this nature exist.[1] The solution to such problems, however, is in terms of the torque which must be applied to the driving link. In many cases, it may be impractical to produce such a torque.

When devices such as springs, solenoids, air or hydraulic cylinders are to be used to supply the driving force in a mechanical system, the second type of system exists. Here input force-displacement relationships are known or can be easily determined. It, therefore, seems desirable to solve for velocities and accelerations resulting from the application of this known force. However, the previously mentioned method does not apply to problems of this type. This article presents a method for solving problems of this type; it may also be applied to problems of the first type.

In the proposed method, an equivalent energy system is used. Other equivalent energy methods[2, 3] have been proposed; however, this method differs in certain respects. The mechanism being analyzed is reduced to an energy equivalent system consisting of a variable mass rotating about a fixed point at the same instantaneous angular velocity and acceleration as the reference link in the actual mechanism. Although a translational system could be used, the rotating system appears to be superior.

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[1] References are tabulated at end of article.

This fictitious system is used only to derive the general equations and methods necessary for the analysis. When applying the energy method to an actual mechanism only the derived equations are used.

Method: Strain energy, potential energy and bearing friction will be neglected. Therefore, the only energies that will be considered are the input, output and kinetic energies of the mechanism. Kinetic energy of a rigid body having plane motion is equal to the kinetic energy due to rotation about its center of gravity plus the kinetic energy due to translation of its center of gravity. The total kinetic energy of a system of rigid bodies is equal to the algebraic sum of the kinetic energy of each body in the system. Therefore, the total kinetic energy E_t of a four-bar linkage, *Fig.* 1, is

$$E_t = \frac{1}{2}\left[I_2\,\omega_2^2 + I_{g3}\,\omega_3^2 + M_3\,V_{g3}^2 + I_4\,\omega_4^2\right] \qquad (1)$$

where I_2 and I_4 are the moments of inertia of links 2 and 4 about their respective centers of rotation. I_{g3} is the moment of inertia of link 3 about its center of gravity G_3. Subscripts with angular velocity ω indicate the respective links. Symbol V_{g3} represents the instantaneous linear velocity of the center of gravity of link 3

If this instantaneous kinetic energy is attributed to a variable mass rotating about a fixed point at an instantaneous angular velocity equal to that of link 2, the input link of the mechanism, it is apparent that the kinetic energy of this variable mass will be

$$E_e = \frac{1}{2}\,I_e\,\omega_2^2 \qquad (2)$$

where I_e is the instantaneous moment of inertia of the variable mass. Equating the two kinetic energy expressions and solving for equivalent moment of inertia, yields

$$I_e = I_2 + I_4\left(\frac{\omega_4}{\omega_2}\right)^2 + I_{g3}\left(\frac{\omega_3}{\omega_2}\right)^2 + M_3\left(\frac{V_{g3}}{\omega_2}\right)^2 \qquad (3)$$

Equation 3 gives a relation between the moments of inertia of each link in the mechanism and the equivalent moment of inertia, when the kinetic energy of the mechanism is referred to link 2. A similar expression will result if a different reference is chosen. A more general expression for the equivalent moment of inertia for any mechanism, regardless of its complexity is

$$I_e = \frac{2}{\omega_r^2}\sum_{k=2}^{k=n} E_k \qquad (4)$$

where ω_r is the angular velocity of the reference link and n is the number of links in the mechanism. The frame, link 1, has no motion.

Ratios in Equation 3 of the angular velocities of the links can be determined by a velocity analysis. Angular velocity ratios are functions of the lengths of the links and the angular positions of the links. Therefore, it is not necessary to know a specific value for the angular velocity of the input link. The analysis is usually carried out assuming a constant angular velocity for the input or reference link. After this velocity ratio analysis has been completed it is possible to construct a curve of the equivalent moment of inertia versus the angular position of the reference link, using Equation 3.

The mechanism is supplied with energy in the form of an input torque T_i, at link 2, and energy is removed in the form of an output torque T_o at link 4. The instantaneous angular velocity of link 2, after link 2 has moved through an angular displacement $\Delta\theta$, can be found by applying the following principle of dynamics: "Work done on a system of particles by all of the external and internal forces in any displacement of the system is equal to the change in the kinetic energy of the system in the same displacement."[4]

Fig. 1 — A representative four-bar linkage. Link 2 is the input link; link 4 is the output link

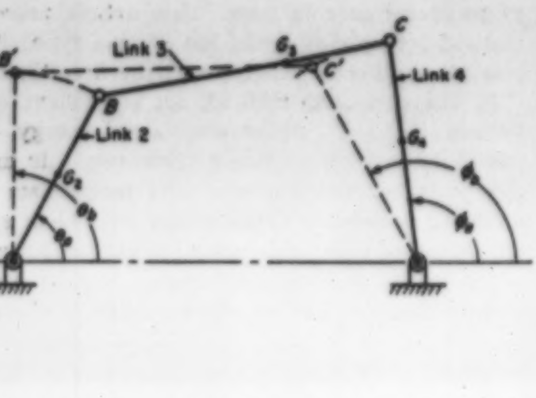
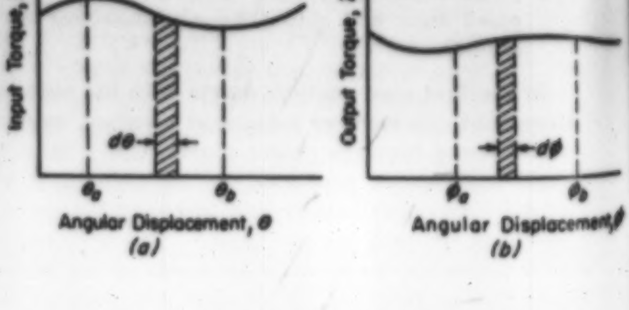


Fig. 2 — Torque-displacement relationships for a representative four-bar mechanism



(a)

(b)

Total work done, on the mechanism, will be equal to the difference between the input and output energies. Input energy, E_i will be

$$E_i = \int_{\theta_a}^{\theta_b} T_i \, d\theta \tag{5}$$

as shown graphically by *Fig.* 2*a*. Output energy E_o will be:

$$E_o = \int_{\phi_a}^{\phi_b} T_o \, d\phi \tag{6}$$

as shown by *Fig.* 2*b*. Limits used to evaluate the output energy from Equation 6 must be compatible with the limits used to evaluate the input energy from Equation 5. Each set of limits should represent the same change in position of the links of the mechanism. To evaluate the energy quantities given by Equations 5 and 6, it will be necessary to know the relation between the torques and their respective angles. If the torque relations are not adaptable to analytical expressions, it will be necessary to construct the two torque curves and by graphical or numerical means evaluate the energy.

Subtracting Equation 6 from Equation 5 and equating this result to the change in the kinetic energy of the equivalent system during the same displacement interval yields

$$\int_{\theta_a}^{\theta_b} T_i \, d\theta - \int_{\phi_a}^{\phi_b} T_o \, d\phi = \frac{1}{2} \left[I_{eb} \, \omega_b^2 - I_{ea} \, \omega_a^2 \right] \tag{7}$$

Subscripts, a and b, indicate the angular positions of the equivalent system and the reference link of the actual mechanism. The equivalent system is rotating at the same angular velocity as the reference link, link 2. Therefore, ω_b will equal the instantaneous angular velocity of link 2 at the angular position θ_b. Solving Equation 7 for the angular velocity yields

$$\omega_b^2 = \left(\frac{2}{I_{eb}} \right) \left(\int_{\theta_a}^{\theta_b} T_i \, d\theta - \int_{\phi_a}^{\phi_b} T_o \, d\phi + \frac{1}{2} I_{ea} \, \omega_a^2 \right) \tag{8}$$

To determine angular acceleration α_b of the reference link at angular position θ_b, Equation 8 is differentiated once with respect to θ, and the relation, $\alpha = \omega (d\omega / d\theta)$, is used to obtain

$$\alpha_b = \frac{T_{ib} - T_{ob} \left(\frac{\omega_{4b}}{\omega_{2b}} \right)}{I_{eb}} - \frac{\frac{dI_{eb}}{d\theta_b} \left[\int_{\theta_a}^{\theta_b} T_i \, d\theta - \int_{\phi_a}^{\phi_b} T_o \, d\phi + \frac{1}{2} I_{ea} \, \omega_a^2 \right]}{I_{eb}^2} \tag{9}$$

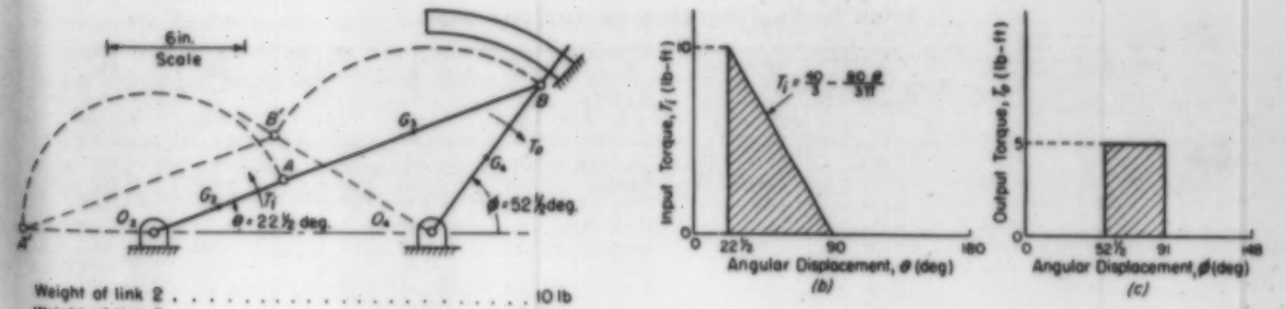
Substitution of Equation 8 in Equation 9 yields

$$\alpha_b = \frac{T_{ib} - T_{ob} \frac{\omega_{4b}}{\omega_{2b}}}{I_{eb}} - \frac{\omega_b^2}{2 I_{eb}} \, \frac{d I_{eb}}{d \theta_b} \tag{10}$$

When performing the differentiation, it must be remembered that the terms I_{eb}, T_i, T_o, and ω_b are functions of the angular position, θ, while I_{ea} and ω_a have specific values as determined at position θ_a.

In Equation 10, the terms T_{ib}, T_{ob}, I_{eb}, $dI_{eb}/d\theta_b$ and ω_{4b}/ω_{2b} are determined for the angular position, θ_b, of the reference link. Torques are obtained from the input and output torque curves. Angular velocity ratio can be determined by graphical methods or from the data used to construct the equivalent moment of inertia curve. The value of the equivalent moment of inertia and the slope are obtained from the equivalent moment of inertia curve.

Angular acceleration could also be obtained by graphical differentiation of the angular velocity


6 in.
Scale
B'
B
A
A'
G3
G2
G4
T_i
T_o
O_2
O_4
$\theta = 22\frac{1}{2}$ deg.
$\phi = 52\frac{1}{2}$ deg.
Input Torque, T_i (lb-ft)
10
0
0
$22\frac{1}{2}$
90
180
Angular Displacement, θ (deg)
$T_i = \frac{40}{3} - \frac{80\,\theta}{3\pi}$
Output Torque, T_o (lb-ft)
5
0
0
$52\frac{1}{2}$
91
148
Angular Displacement, ϕ (deg)

Weight of link 2	10 lb
Weight of link 3	3.22 lb
Weight of link 4	10 lb
Moments of inertia of links 2 and 4 about their respective centers of rotation	0.0314 slug-ft^2
Moment of inertia of link 3 about its center of gravity	0.020 slug-ft^2

(a)

(b)

(c)

Fig. 3—Design data for analysis of a four-bar linkage

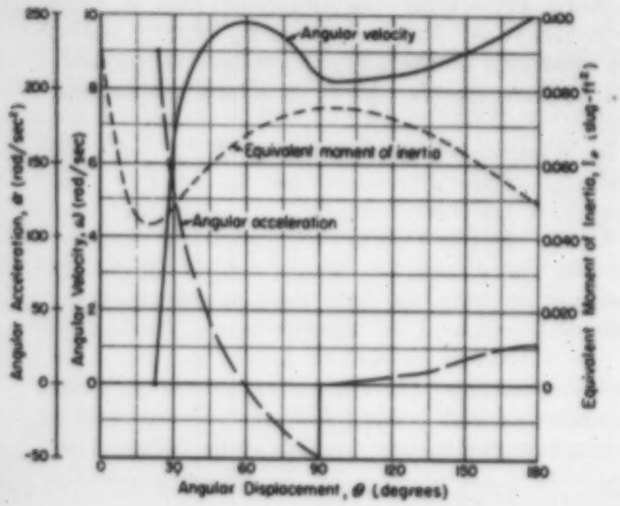
versus the angular displacement curve which is constructed using the results of Equation 8. However, both methods require one graphical differentiation and would introduce approximately the same error in the analysis.

To determine the time required for the linkage to move through a particular displacement, it is necessary to construct a curve of the reciprocal of the angular velocity, $1/\omega$ versus the angular displacement of the reference link. Equation 8 is used to compute the angular velocity. The area under this curve, within the displacement limits, will then represent the time. This is expressed by

$$t_b - t_a = \int_{\theta_a}^{\theta_b} \frac{1}{\omega}\, d\theta \qquad (11)$$

Examples: Detailed analyses of a four-bar circuit breaker mechanism and a slider crank mechanism serve to illustrate the application of the method. Although not specifically demonstrated, the method may also be used with mechanisms incorporating cams.

Fig. 4—Dynamic characteristics of the mechanism shown in *Fig. 3a*



Data for a four-bar mechanism are shown in *Fig. 3a*.

The mechanism starts from rest at a position where $\theta = 22\frac{1}{2}$ degrees. It is subjected to an input torque that is represented graphically in *Fig. 3b* and an output torque that is represented in *Fig. 3c*. Angular velocity and acceleration curves for link 2 are constructed for the displacement interval represented by $\theta = 22\frac{1}{2}$ degrees to $\theta = 180$ degrees.

First, Equation 3 is used to construct the equivalent moment of inertia curve. A sample computation at $\theta = 30$ degrees is

$$I_e = 0.0314 + 0.0314\,(0.281)^2 + 0.020\,(0.340)^2 + 0.1\,(0.333)^2 = 0.047 \text{ slug-ft}^2$$

Velocity ratios in Equation 3 are determined from a velocity vector polygon. The velocity polygon is drawn for a sufficient number of phases to construct the equivalent moment of inertia curve. Data obtained from the polygons and the information required to construct the curve are tabulated in columns 2, 3, 4 and 5 of *Table* 1. The equivalent moment of inertia versus the angular displacement curve is shown in *Fig*. 4. Only the portion of the curve from $\theta = 22\frac{1}{2}$ to $\theta = 180$ degrees is shown. However, the curve for the complete motion cycle of the mechanism can be helpful. If this mechanism were to be used for opening an electrical switch, an investigation of this curve would indicate where the closed position should be such that the least torque will be required to start opening the switch. The curve will also indicate whether the changing inertia of the mechanism will tend to slow down the mechanism after the input and output torques have stopped acting.

Second, the angular velocity curve for link 2

Table 1—Four-Bar Linkage Analysis Data

1 θ (degrees)	2 ω_4/ω_2	3 ω_3/ω_2	4 V_{g3}/ω_2	5 I_e (slug-ft²)	6 $dI_e/d\theta$ (slug-ft²/rad)	7 $E_i - E_o$ (lb-ft)	8 T_i (lb-ft)	9 T_o (lb/ft)	10 ω rad/sec	11 α rad/sec²
22½	0.050	0.470	0.263	0.043	0	0	10	5	0	227
30	0.281	0.340	0.333	0.047	0.048	1.06	8.89	5	6.70	137
37½	0.434	0.250	0.389	0.054	0.044	1.94	7.78	5	8.46	74.6
45	0.532	0.187	0.424	0.059	0.033	2.55	6.67	5	9.30	43.8
52½	0.575	0.173	0.435	0.063	0.030	2.98	5.56	5	9.70	20
60	0.664	0.100	0.467	0.067	0.024	3.24	4.45	5	9.80	−0.4
67½	0.700	0.085	0.480	0.070	0.018	3.28	3.34	5	9.69	−14.3
75	0.725	0.050	0.492	0.072	0.012	3.22	2.22	5	9.45	−27.0
82½	0.742	NIL	0.490	0.074	0.005	2.95	1.12	5	8.95	−37.8
90	0.750	0.008	0.500	0.074	0	2.54	0	5/0	8.39	−50.6/0
105	0.750	0.021	0.500	0.074	−0.004	2.54	0	0	8.39	1.9
120	0.725	0.059	0.490	0.072	−0.010	2.54	0	0	8.40	4.9
135	0.682	0.100	0.475	0.069	−0.017	2.54	0	0	8.60	9.1
150	0.600	0.162	0.445	0.063	−0.028	2.54	0	0	8.95	17.9
165	0.482	0.241	0.400	0.056	−0.028	2.54	0	0	9.55	22.7
180	0.338	0.330	0.349	0.049	−0.024	2.54	0	0	10.10	25.2

is constructed using Equation 8. Since the mechanism starts from rest, $\omega_a = 0$ at $\theta = 22\frac{1}{2}$ degrees and Equation 8 can be simplified to

$$\omega_b^2 = \frac{2}{I_{eb}} (E_i - E_o)$$

where

$$E_i = \int_{\theta_a}^{\theta_b} \left(\frac{40}{3} - \frac{80\,\theta}{3\,\pi} \right) d\,\theta$$

To be valid, all values of θ must be between $22\frac{1}{2}$ and 90 degrees and must be expressed in radians. Limits of integration are $22\frac{1}{2}$ for the lower limit and, of course, the upper limit is the point for which the computation is to be performed.

Limits for

$$E_o = \int_{\phi_a}^{\phi_b} 5\,d\,\phi$$

are the displacement angles corresponding to those in the expression for E_i. The upper limit is taken from the velocity vector polygon while the lower limit is $52\frac{1}{2}$ degrees.

Result of a sample computation at $\theta = 30$ degress is

$$\omega_b = \sqrt{\frac{2}{0.047}(1.06)} = 6.70 \text{ rad/sec}$$

Table 1, column 10, contains the results of computations based on Equation 8. These data are plotted, *Fig*. 4, to represent graphically the angular velocity of link 2 versus the angular displacement.

Third, the angular acceleration curve for link 2 is constructed using Equation 10.
A sample computation at $\theta = 30$ degrees is

$$\alpha_b = \frac{8.89 - 5(0.281)}{0.047} - \frac{6.7^2}{2(0.047)}(0.048) =$$
$$137 \text{ rad/sec}^2$$

Construction of the angular acceleration curve, using Equation 10, requires three intermediate steps. First, the values of angular velocity ω for the number of positions required to represent a complete motion cycle must be tabulated. Second, equivalent moment of inertia I_e must be tabulated for the same positions. Third, slope $dI_e/d\theta$ of the equivalent moment of inertia curve must be determined at each of these positions. Columns 5, 6 and 10 of *Table* 1 contain this information. Column 11 contains the computed angular acceleration of link 2. Angular acceleration of link 2 is plotted in *Fig*. 4 versus the angular displacement.

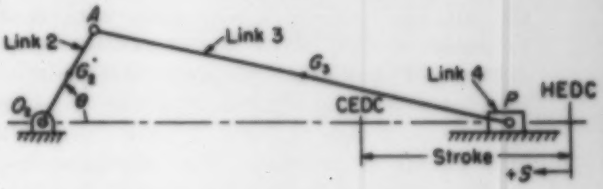
Results obtained from the above methods can be checked by assigning the computed values of the angular velocity and acceleration, at one position, to the mechanism and solving for the resulting unbalanced torque on link 2 by the method previously mentioned.[1]

The slider-crank mechanism shown in *Fig*. 5 can be analyzed in much the same way. The mechanism starts from rest at a position corresponding to $\theta = 0$ degree. The piston is subjected to an input force which decreases linearly from the head-end dead-center position. The force-displacement relation is expressed analytically as

$$F_i = 100 - 200s$$

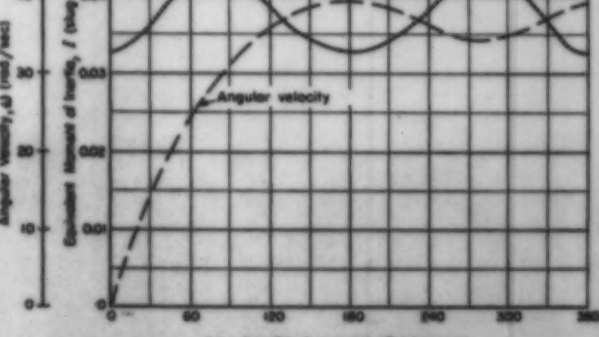
where s is the linear displacement, in feet, of the piston. It is measured positively from the head-end dead-center position. The input force is equal to zero at the crank-end dead-center position. The mechanism completes the remaining one-half cycle without energy being supplied or removed. In this example it is assumed that the input force on the

Fig. 5 — Slider-crank mechanisms which can be analyzed by the equivalent energy method



Weight of link 2	3.22 lb
Weight of link 3	3.22 lb
Weight of piston	3.22 lb
Moment of inertia of link 2 about its center of rotation	0.030 slug-ft²
Moment of inertia of link 3 about its center of gravity	0.020 slug-ft²

Fig. 6—Equivalent moment of inertia and angular velocity of the slider-crank mechanism, *Fig*. 5



piston can cause turning of the crank when the mechanism is at the head-end dead-center phase.

The equivalent moment of inertia curve of the mechanism, *Fig.* 6, is very nearly sinusoidal in nature and the portion of the curve from 180 to 360 degrees is a mirror image of the portion from 0 to 180 degrees. *Fig.* 6 also shows the angular velocity curve for link 2 during one motion cycle.

Applications: A complete force analysis using this method can produce many useful results. For example, energy remaining in a linkage after it has performed its function can be computed and put to good use in the design of a stop or bumper. Additionally, examination of the equivalent moment of inertia curve may show that a change in starting position could result in faster action, less residual energy or perhaps permit use of a smaller input device.

REFERENCES

1. C. W. Ham and E. J. Crane—*Mechanics of Machinery*, Third Edition, McGraw-Hill Book Co. Inc., New York, 1948, Pages 337-342.
2. B. E. Quinn—"Energy Method for Determining Dynamic Characteristics of Mechanisms," *Journal of Applied Mechanics*, Vol. 71, 1949, Pages 283-288.
3. R. C. Van Sickle and T. P. Goodman—"Spring Actuated Linkage Analysis to Increase Speed," *Product Engineering*, Vol. 24, No. 7, 1953, Pages 152-157.
4. M. S. Seely and N. E. Ensign—*Analytical Mechanics for Engineers*, Third Edition, John Wiley and Sons Inc., New York, 1948, Page 299.

Investment Casting Designs

DESIGN advantages of the investment casting process for special situations are well portrayed by several current case histories. Although the process requires a new mold with each part produced, it often leads to cost savings in the production of intricate one-piece components. Or, because machining after casting can be reduced or eliminated, design of parts in virtually nonmachinable metals is practical. The accompanying case studies, supplied by the Investment Casting Institute, show several representative applications.

As an example of large parts produced by the process, *Fig.* 1 illustrates a nozzle casting of alloy type 310 stainless steel. This casting is used in the aircraft industry. Weighing about 50 pounds as cast, the part measures 13.6 inches in outside diameter. The 15 blades are used as-cast. Since plastic is used rather than wax as the expendable material, functional dimensions can be held to close limits.

Another cost savings was realized in making the conveyor part illustrated in *Fig.* 2. The original part shown at the top was made from a metal stamping, two screw machine parts and a hardened steel bushing. By contrast, the part on the bottom was investment cast in one piece. Also, by making it from an air-hardening tool steel, further heat treating was unnecessary.

Long narrow slots cast to unusually close tolerances are another advantage of investment casting as demonstrated by the piece illustrated in *Fig.* 3. The part was successfully cast to close tolerances required because of the ability of investment castings to accurately allow for metal shrinkage.

Fig. 1—Below—Nozzle for aircraft use is cast in one piece. The 15 blades may be used as cast

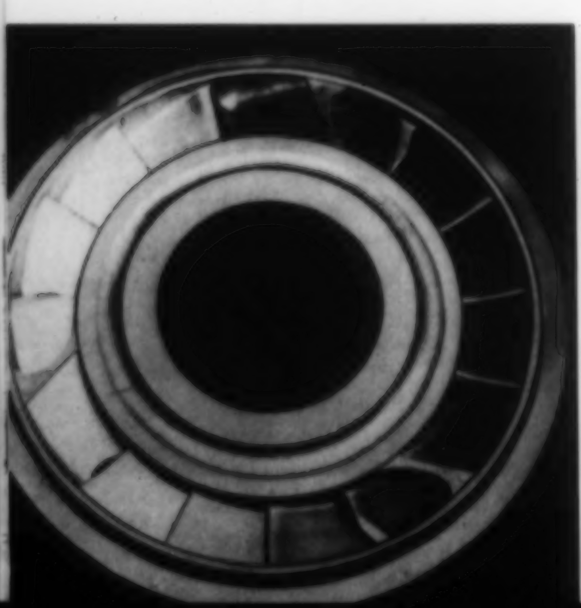


Fig. 2—Below—Original part, top, was made up of four parts and required a number of separate operations to produce. Investment cast part, bottom, was cast in one piece and does not require further machining

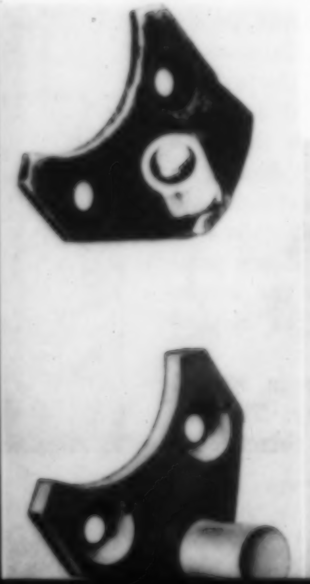


Fig. 3—Below—Precise casting of long, narrow slots to close tolerances is possible as shown by this weld pocket used in the lamp industry

Low-Expansion Cast Iron

Properties and design characteristics of a nickel cast iron capable of holding precision dimensions under local heating conditions

By Harold Brown
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WHENEVER dimensional tolerances on the order of 0.0001-inch are significant, the designer of precision machines may well study the influence of temperature changes within the individual manufactured parts composing the machine. Undesirable expansion effects may be found, caused by local heating from friction and cutting, or lubricating or hydraulic oil.

In recent years, precision equipment has been made of metals having low coefficients of thermal expansion. For example, the spindle housings of precision drilling, boring and grinding machines are often made from a low-expansion nickel cast iron. Scientific instruments, gages and measuring devices, *Fig.* 1, and valves are other examples. Castings of this 36 per cent nickel alloy, called Min-o-var, have been successful in precision machines. In addition to a low coefficient of expansion, Min-o-var has other advantageous characteristics such as gall resistance, vibration-damping capacity, machinability of graphite cast iron, and good corrosion resistance.

The linear coefficient of expansion of this alloy of 2.2×10^{-6} in. per in. per deg F is about one-third that of cast iron (6.3×10^{-6} in. per in. per deg F). To illustrate the gain obtained from a low-expansion alloy, suppose friction in a spindle head causes temperature to rise 20 F above room temperature. If the head is made of this low-expansion iron, two spindles 16 inches apart will separate only 0.0007-inch. If the heads were plain cast iron, the two spindles would separate 0.002-inch.

Properties of Min-o-var are listed in *Table* 1. It has a lower coefficient of expansion and greater toughness than gray iron. These properties are combined with equal resistance to galling, vibration damping capacity, stiffness and compressive strength.

Chemical composition is 2.40 max total C, 1.0-2.0 Si, 0.50 max Cr, balance Fe. If total carbon exceeds 2.40 per cent, an open-grained structure is formed and reduction in strength occurs. Silicon is adjusted to the section thickness in the same manner as for similar sections of gray iron. Chromium should be held to a maximum of 0.10 per

Fig. 1—Low-expansion cast iron is used for the housing of this precision gage, which controls steel strip thickness in the mill. Variations of 0.0001-inch are magnified and recorded

Photo, courtesy Pratt and Whitney Div., Niles-Bement-Pond Co.

cent to avoid an increase in the coefficient of expansion.

Nickel content should be within the limits of 34 and 36 per cent. The curves of *Fig.* 2 show that nickel content outside these limits causes an increase in the expansion coefficient. The influence of the usual impurities, sulphur and phosphorus are inconsequential in the ranges of 0.04-0.12 per cent sulphur and 0.05-0.020 per cent phosphorus.

Microstructure of Min-o-var is similar to gray iron in that graphite flakes are dispersed through it, as shown in *Fig.* 3. This gives the alloy gall resistance and vibration-damping capacity comparable to gray iron, for finely dispersed graphite is regarded as one of the best inhibitors of wear and of seizure of metal-to-metal bearing parts, such as machine-tool ways, spindle housings and instrument ways. Although strength can be increased by more and larger particles of hard carbide, machinability is impaired.

Min-o-var is utilized in the cast form only. Since

Table 1—Properties of Min-O-Var Low-Expansion Cast Iron

Mean coefficient of expansion, in./in./deg F*	
50-125 F	2.18×10^{-6}
50-200 F	2.24×10^{-6}
50-300 F	2.40×10^{-6}
50-400 F	2.75×10^{-6}
Strength, thousand psi	
Tensile	20-25
Compressive	80-100
Torsional	30-35
Transverse properties, ASTM type B bar	
Load, lb	1800-2000
Deflection, in.	0.6-0.9
Modulus of elasticity, million psi	
Tensile (at 25% of tensile strength)	10.5
Torsional	4.5
Endurance limit, psi	9900
Hardness, brinell	100-125
Impact strength, ft-lb†	150
Pattern shrinkage, in. per ft	3/16
Specific gravity	7.6
Density, lb per cu in.	0.275
Melting point, F	2250
Thermal conductivity, cal/cc/sec/deg C	0.094
Electrical resistivity, microhm per cc	160-170
Magnetic response, per cent of gray iron	about 70

*Alloy having 35 per cent nickel. †Unnotched arbitration bar struck 3 inches above supports.

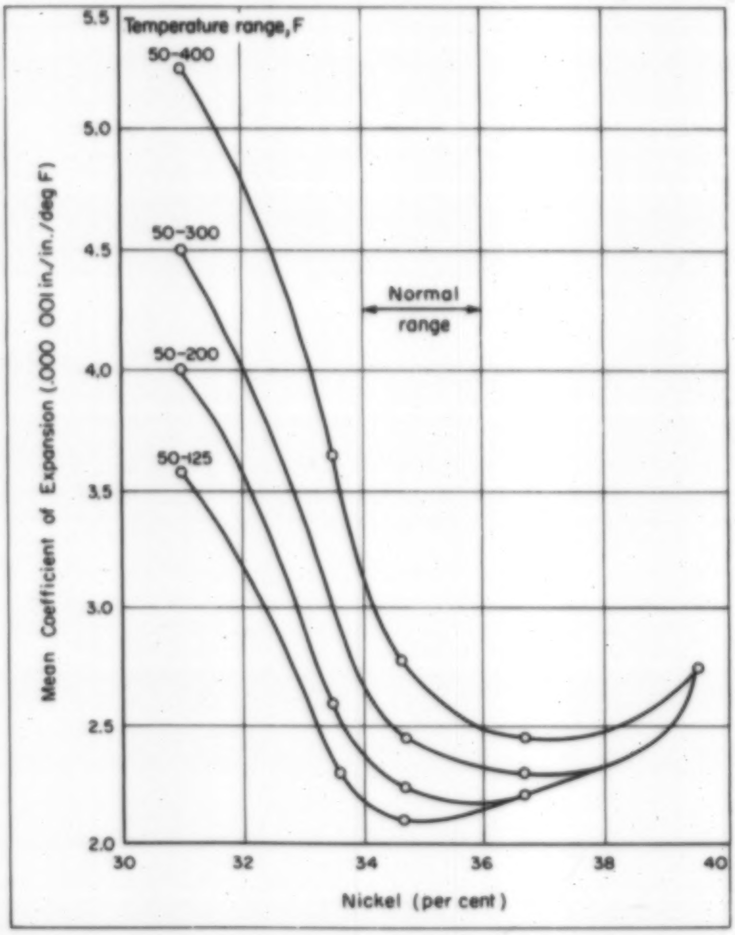
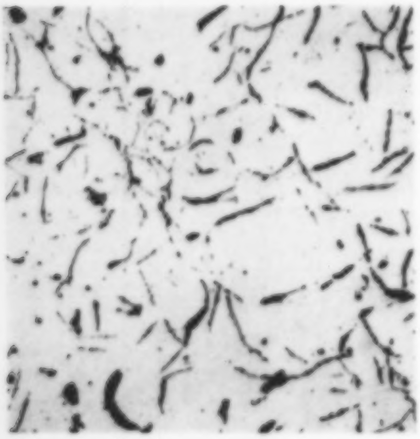


Fig. 2—Right—How mean coefficient of expansion varies with differences in nickel content over four temperature ranges. Specimens have been annealed at 1000 F for 1 hour and air cooled

Fig. 3—Below—Graphite flake dispersion similar to gray iron gives excellent machinability and vibration-damping capacity



pattern shrinkage is 3/16-inch per foot, patterns made for gray iron may have to be adjusted for greater shrinkage when the low-expansion alloy is cast. Large and intricate castings of Min-o-var iron can be made as readily as gray iron castings and with no more difficulties in the foundry, providing the usual precautions in handling special alloys are observed. Machinability of Min-o-var is about the same as that of gray iron of 200 brinell hardness. Scraping, reaming and other fine finishing operations can be done readily.

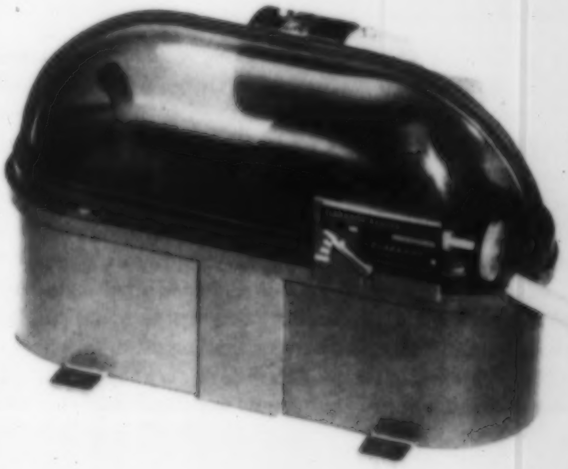
Since the castings are used primarily where dimensional stability is imperative, annealing to remove strains resulting from casting and rough machining is desirable. Stress-relief annealing at 1100 to 1200 F for one hr per inch of thickness, followed by cooling in the furnace, is recommended for optimum dimensional stability.

Although Min-o-var iron is austenitic, it has about 70 per cent of the magnetic response of gray iron at room temperatures. This is significant to the final product as well as in its fabrication. For example, when a casting of Min-o-var is supported for machining by a magnetic chuck, the holding force will be only about 70 per cent of that for gray iron.

Chemical Feeder Made Entirely of Plastic

A NEW precision liquid chemical feeder is made entirely of plastic except for the motor and nameplate. All parts such as shafting, float valve, screws and nuts are of unplasticized Geon vinyl resin, used because of its acid and chemical resistance. Top cover is molded of transparent sheet to permit viewing of the liquid content and functioning of the mechanical parts.

Manufactured by the Clarkson Co., the feeder is 12 inches wide, 20 inches long, 14 inches high and weighs 20 pounds. Rate of flow from the feeder can be adjusted from a few drops per minute to 750 gallons per day.



CONTEMPORARY DESIGN

Lights Signal Hardness In Testing Machine

THREE colored lights are used to signal relative Brinell hardness of the test piece in a recently introduced testing machine. Made by Steel City Testing Machines Inc., the Color-Glance tester uses a dial indicator with adjustable electrical contacts to light the appropriate indicator light. Red indicates a part is too soft, yellow that it is too hard, and green that it is within limits. The machine cycle is completely automatic except for loading, unloading and starting. Two sizes of machine having 6 or 10-inch throat depths are available.

Design Manual

Mechanical Adjustable-

Part 2

PRINCIPLES and operating characteristics of mechanical systems for stepped and stepless, limited-range speed adjustment have been treated in detail in a previous article. In this, the concluding article of a two-part design manual, attention will be focused on two other important aspects of mechanical speed control. The following section will discuss speed changers of the stepless, infinite-range type. A succeeding section will consider overall selection and application factors for mechanical adjustable-speed systems.

For convenience in classification, the term "infinite-speed range" has been adopted here to identify those mechanical systems which include zero output speed in their normal operating range. This terminology is commonly used and stems from the fact that the speed ratio of such devices usually cannot be assigned a rational value due to zero or negative speed values. Actually, however, these units have a definite operating speed range with a positive maximum speed value at one limit and either a zero or negative (reverse) value of speed at the other. In practice, systems of the infinite-range type are often suitable for the same applications as limited range units, particularly where output speeds fall in the low range.

Stepless Speed Adjustment—Infinite Range

Zero output speed can be produced from a rotating input by several mechanical techniques. The fundamental principles are well known and today serve as the basis of a number of efficient adjustable-speed drive systems of the stepless, infinite-range type.

Most commercial infinite-range speed changers utilize some form of planetary or differential action for operation at zero speed, although one successful design employs the variable-stroke impulse principle discussed previously. Other methods, such as the wheel-and-disk systems, are also finding useful application under certain types of operating conditions.

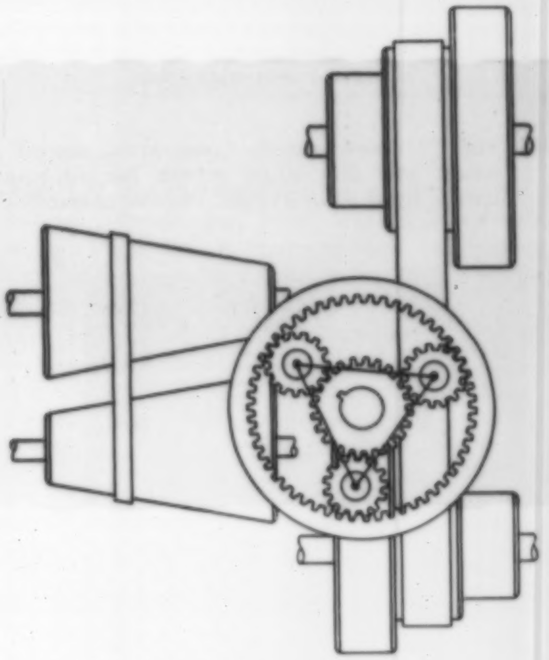
In this discussion, only those systems now in general use will be considered. Many other methods that are operationally practicable have been proposed, and tried, but performance characteristics and cost considerations have either limited or discouraged design application and acceptance.

The basic advantage of the infinite-range systems lies in the flexibility of speed control that is possible. Range of output speed variation is usually from zero to a specified maximum speed value; however, most of the speed changer designs can be readily modified to provide stepless speed adjustment over a range extending through zero to some maximum speed value in the reverse direction of rotation. Machine performance can thus be accurately controlled, from a standstill, to match load requirements over the full operating speed range. This feature is particularly significant when starting and stopping or acceleration and deceleration requirements are critical.

Low-speed operation is another infinite-range system characteristic which may offer potential advantages. In contrast to limited-range devices which usually require some form of auxiliary reduction drive as speeds approach zero, the infinite-range systems can usually be coupled directly to the load, simplifying installation problems. At the same time, however, the infinite-range units

By Leo F. Spector
Associate Editor
Machine Design

Speed Drives



usually involve a greater degree of mechanical complexity and first costs, and maintenance will probably run higher. Selection may have to be justified on the basis of performance objectives.

Wheel and Disk Systems: One of the oldest mechanical methods of speed adjustment is the simple wheel and disk system shown schematically in *Fig.* 71. This principle has been applied in modified form to a number of different speed changer designs of both the infinite and limited-range types, *Fig.* 60. Many of the early devices were ill-fated and failures were frequent, usually as a result of improper application under excessive load conditions. In these systems, torque capacity is limited by the nature of the speed-changing mechanism. As a result, infinite-range units of this type are only suitable for extremely low-power applications where contact forces, and torque, are small. Higher torque capacities could, of course, be achieved under limited-range operating conditions but minimum output-speeds would have to be established accordingly to prevent slipping and failure at the contact surfaces.

For the system shown in *Fig.* 71, speed adjustment is accomplished by varying the position of the wheel with respect to the center of the disk, thus changing the drive ratio. With the wheel at the disk center, output speed is zero. If the wheel is moved to the opposite side of the disk center, the direction of rotation of the output shaft will be reversed.

Either the wheel or the disk can serve as the driving member; however, the most common arrangement has the disk as the output or driven member, *Fig.* 71*a*. Power is usually transmitted to the wheel in one of two ways: (1) Through a shaft which serves as the wheel axle, *Fig.* 71*a*, or (2) by means of a second disk also in frictional contact with the wheel, *Fig.* 71*b*.

Ideally, there should be only point contact between the wheel and disk if a pure rolling action is to be achieved. This condition is an inherent weakness of the wheel and disk systems and cannot be attained in practice, although it can be approached under low-power loads. Wheel surfaces are usually rounded to cut down contact area. However, both contact surfaces are subject to deformation under load, resulting in a certain degree of sliding action and wear.

An interesting example of a recent application of the wheel and disk principle is furnished by the phonograph drive shown in *Fig.* 72. The arrangement is closely similar to the one depicted in *Fig.*

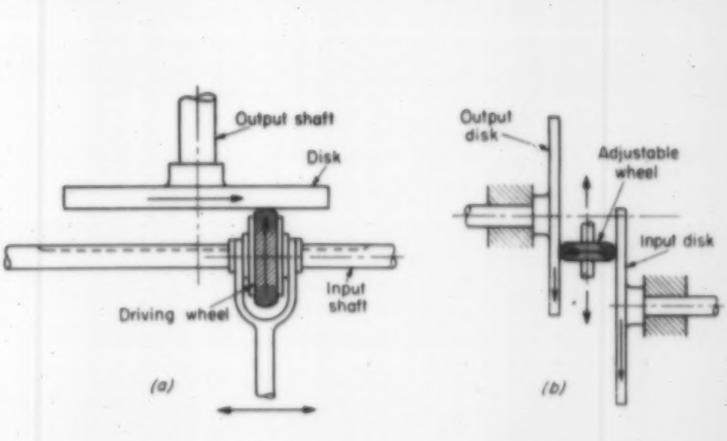


Fig. 71—Basic wheel and disk system, *a*, for stepless, infinite-range speed adjustment. Output speeds are varied by moving the wheel in and out from the center of the disk. Modified design, *b*, utilizes second disk, instead of shaft, to transmit power to wheel

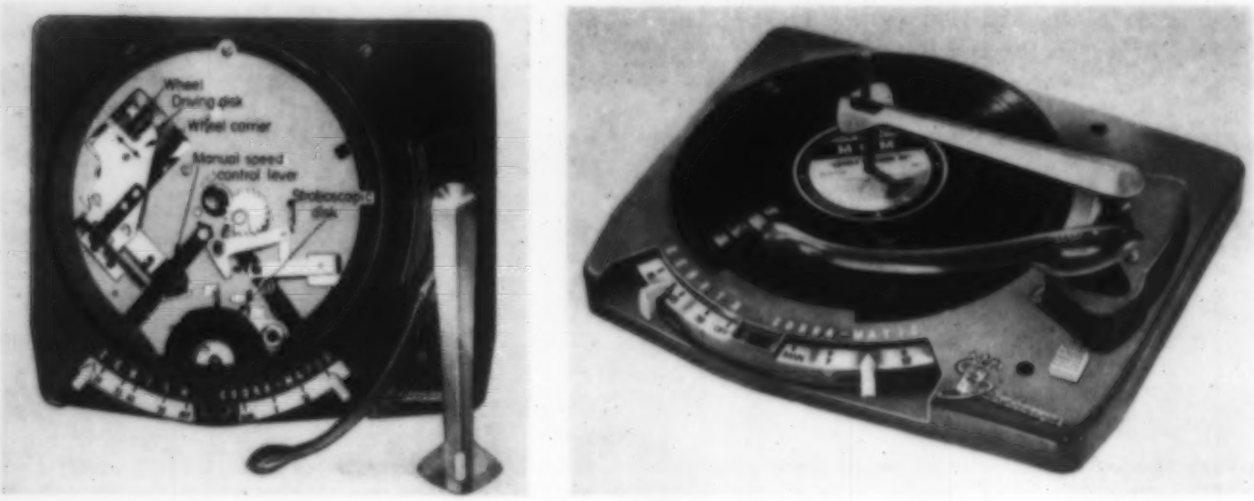


Fig. 72—New Zenith Cobra-Matic record changer showing wheel and disk drive system for adjustment of turntable speeds from 10 to 85 rpm. Photos, courtesy Zenith Radio Corp.

71*b*, with the wheel serving as an idler between a driving disk and the bottom surface of the turntable. Stepless adjustment of turntable speeds from 10 to 85 rpm is obtained by means of a manual lever, mounted on a graduated scale, which controls the position of the wheel on the face of the driving disk. Exact reproduction of the standard record speeds of 33⅓, 45 and 78 rpm is assured by a built-in stroboscopic disk assembly, employing three graduated scales of dots and a 60-cycle, flashing neon bulb for visual speed synchronization.

A modified version of the basic wheel and disk arrangement that has been used to advantage in delicate mechanisms employs a roller and a spherical shaped disk, *Fig.* 73. Pure rolling contact is provided but the design is only practical for light loads. Output speeds are varied by pivoting the roller on the spherical surface of the driving disk to change the effective drive ratio. Infinite range, including reverse speeds, can be obtained.

Differential Transmissions: A fundamental problem in infinite-range adjustable-speed systems is the control of torque at low, and zero, speeds. Obviously, any transmission capable of producing zero speed cannot, over the full speed range, also have a constant horsepower characteristic, which would involve the impossible condition of infinite torque capacity. One practical approach to the problem is provided by the differential systems which employ some type of limited-range speed changer in combination with an epicyclic, or differential, gear train. Transmissions of this type offer a high degree of flexibility in application and can be developed to meet a wide range of torque and speed requirements. Most of the units are designed to provide a constant minimum torque rating across the entire range to zero speed with maximum torque values of double, or more, the minimum values possible in the low-speed portion of the range. However, performance characteristics will vary with the particular design.

In practice, the differential systems may take many different forms although the operating principles are essentially the same. The transmission design for an early water wheel governor shown in *Fig.* 74 illustrates a basic arrangement that is perhaps the forerunner of most of the systems in use today.

In this early design, a bevel gear differential has been combined with a limited-range cone pulley set to regulate the supply of water to a rotating wheel. Belt position, and output speed, are controlled through a ball governor and lever-operated shifting forks. Operation of the governor is such that the belt is in the center position when the wheel is running at normal operating speed, providing a 1:1 drive ratio between the cones. Both input gears of the differential train will then rotate at equal speeds, in opposite directions, and the spider, and output shaft, will not be turning. As the belt is moved from this center position, however, the input bevel gears will have different speeds and the output shaft will rotate in the same direction as the gear with the highest speed.

Although this early system has now been largely replaced by more advanced and efficient designs, it does provide a simple picture of the basic mechanical elements employed. Present transmissions use both planetary and bevel-gear differentials in either single or multiple, series and parallel, combinations to meet different output requirements. Limited-range transmissions are usually of the variable-pitch pulley type with parallel shafts; however, almost any of the various stepless speed-changers discussed previously would be equally suitable. In one modified design which is based on planetary metallic traction and will be discussed later, the gear differential and speed changer are combined as an integral unit.

Needless to say, the possibilities are virtually unlimited. Through modification of the characteristics of the different operating elements, transmissions can be designed to provide almost any maximum speed within the range of normal machine requirements, and, of course, all units are capable of operation at zero and reverse speed. Capacities ranging from fractional to several hundred horsepower are possible, although designs in the higher horsepower ranges are subject to certain operating limitations of the speed changing mechanism.

Design and application of differential drive systems are, unfortunately, subject to certain pitfalls which are not readily apparent. Basically, the problem centers around a "circulating power" characteristic which, at low speeds, can produce torques of destructive magnitude. Calculation of speed and power relationships in mechanical differential circuits has been treated elsewhere in the literature but it may perhaps be helpful to point out some of the general considerations which must be taken into account.

For systems of the type shown in *Fig*. 74 where the differential and speed changing elements are separated, power from the prime mover divides into two paths as it passes through the system. These two paths rejoin at the output end to transmit a net power value equal to the input power minus losses. Under certain conditions, however, the effective power circulating within the branches may be considerably greater than the input power, leading to excessive efficiency losses and overloading of the drive elements. This characteristic is due to the fact that it is possible to have a negative

Fig. 73—Modified wheel and disk system for infinite-range speed adjustment of delicate mechanisms. Output speed is varied by pivoting roller about spherical surface of driving disk

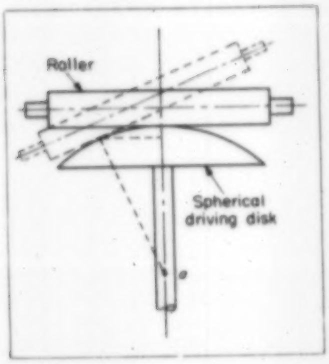
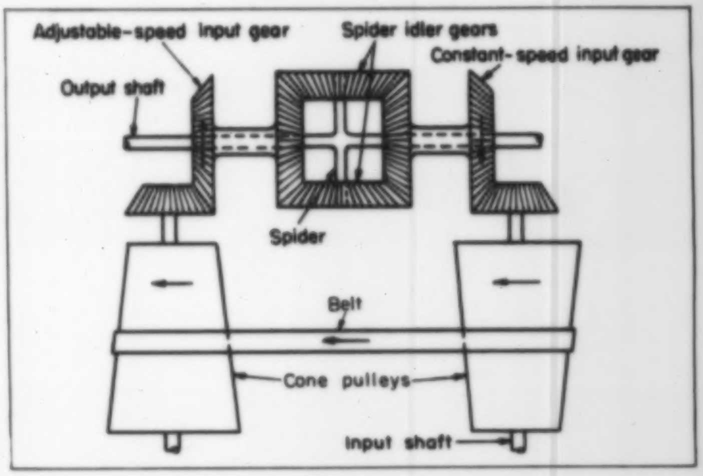
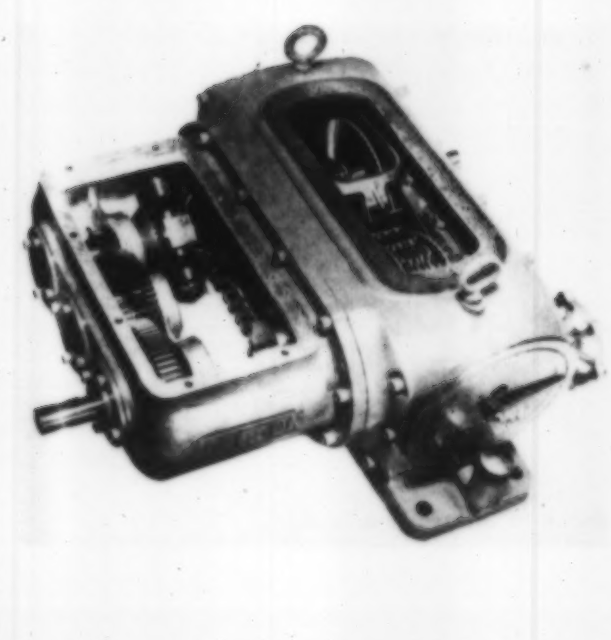

Roller
Spherical driving disk
a

Fig. 74—Right—Basic differential system employing cone pulleys in combination with a differential bevel gear train to provide stepless, infinite-range speed adjustment in an early water-wheel governor design


Adjustable-speed input gear
Spider idler gears
Constant-speed input gear
Output shaft
Spider
Belt
Cone pulleys
Input shaft



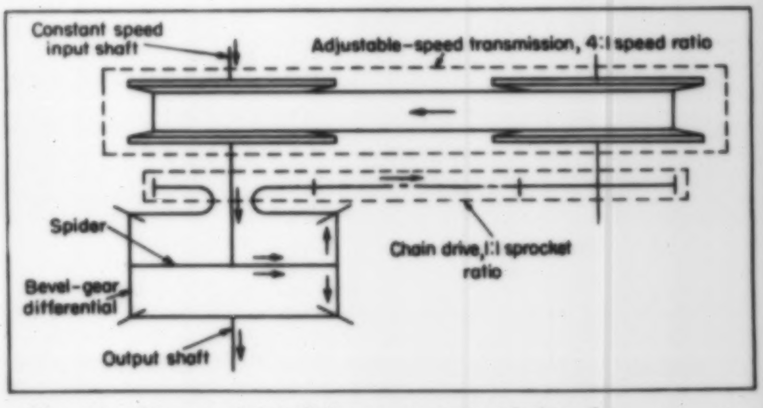

Constant speed input shaft
Adjustable-speed transmission, 4:1 speed ratio
Spider
Chain drive, 1:1 sprocket ratio
Bevel-gear differential
Output shaft

Fig. 75—Commercial infinite-range transmission design which employs bevel gear differential in combination with all-metal limited-range speed changer of type shown in *Fig*. 29. Arrows in schematic diagram of system arrangement indicate direction of power flow. Photo and sketch, courtesy Speed Control Div., Fairchild Engine and Airplane Corp.

value of power flow in one of the branches with an equalizing power buildup in the other. Low, zero and reverse output speeds are typical operating conditions which tend to produce this power unbalance.

This internal circulating power is the price paid for wide speed range and necessitates that operating elements of the system be of sufficient size to handle all load conditions. Depending on output requirements, power in the branches may be as high as six times the input. Failure to properly match transmission and load characteristics may produce a destructive overloading of the drive elements. Properly applied, however, the differential system offers a number of performance advantages including wide range and accuracy of speed control. Costs will run comparatively high since these systems represent a combination of two mechanical drive units.

The differential system also has a further utility in certain special "bypass" power arrangements. In these applications, the power transmitted through a differential gear train is controlled by a speed-changer with a capacity of only a fraction of the total power. Range of speed variation is limited, but under proper conditions a highly accurate and economical adjustable-speed drive may be achieved. Design and application considerations for these types of drives will be discussed in greater detail in the next section.

A modern commercial version of the water wheel governor system, *Fig.* 74, is shown in *Fig.* 75. This design employs a limited-range transmission of the all-metal type, *Fig.* 29, in combination with a bevel-gear differential. Standard models are available for input ratings from 1½ to 20 hp, providing torque capacities at zero speed of either 200 per cent maximum rated torque in the 1½ to 15 hp range, or 50 per cent rated torque in the 2 to 20 hp range. Typical performance curves for both types of units are shown in *Fig.* 76.

Maximum output speeds vary from 80 to 3870 rpm in the 2 to 20-hp series, from 160 to 7000 rpm in the 1½ to 15-hp group; all units go to zero speed. Rated torque capacities range from about 10 to 15,500 lb-in. Several torque and speed combinations are offered in each model size. Standard input speeds are 580, 690 and 860 rpm, necessitating an auxiliary reduction drive for operation with 1750 and 1160 rpm motors. Models with built-in reduction gearing on the input and/or output ends can be obtained.

Mounting and control possibilities are about the same as those discussed previously for the all-metal transmission alone; operation can be manual, semiautomatic or automatic. Typical applications include a number of different industrial processing operations which involve the continuous movement of flat widths of material, the mixing of foods, chemicals, liquids, etc., and other similar jobs where speeds may have to be varied continuously over a wide range going to or near zero speed. The units are self-contained and operate, fully enclosed, in an oil bath.

Motors, transmissions and load requirements must be carefully matched to avoid overloads from the circulating power flow in the differential circuit. Transmissions should be selected so that the speed-torque characteristics of the load do not at any time exceed the limitations defined by the performance curves, *Fig.* 76. When output speeds fall below the maximum rated value, horsepower capacity must also drop to prevent excessive loads on the unit. For example, if a unit of the type

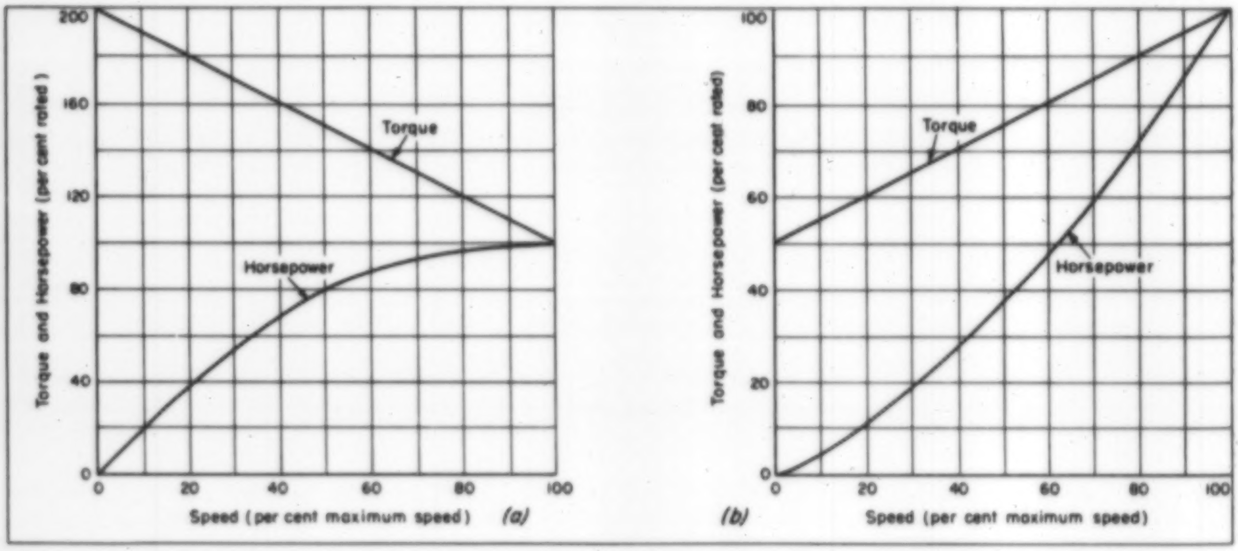


Fig. 76—Typical performance curves for transmissions of the type shown in *Fig.* 75. Curves correspond to units providing torque capacities at zero speed of, *a*, 200 per cent maximum rated torque and, *b*, 50 per cent rated torque. Drawings, courtesy Speed Control Div., Fairchild Engine and Airplane Corp.

represented by the curves in *Fig.* 76*a*, is operated at half-speed, the maximum allowable output power that can safely be transmitted is 75 per cent of the rated horsepower. For units corresponding to *Fig.* 76*b*, half-speed operation reduces horsepower capacity to 36 per cent of rated. In all cases, the torque curves give the maximum allowable output torque for a given horsepower output.

A modified form of this unit has also been developed in which the limited-range transmission is replaced by a dc motor-generator combination electrically coupled in a closed loop and mechanically coupled by a double differential gear box. Standard horsepower capacities run about the same as for the all-mechanical units, although much higher ratings, up to several hundreds of horsepower, are feasible. High flexibility and accuracy of speed control are obtained with the design which incorporates the advantages of both adjustable-voltage dc and differential systems. These units are particularly suited to automatic operation and have been utilized to advantage in processing and production equipment where close control of torque and speed over a wide range is an important requirement.

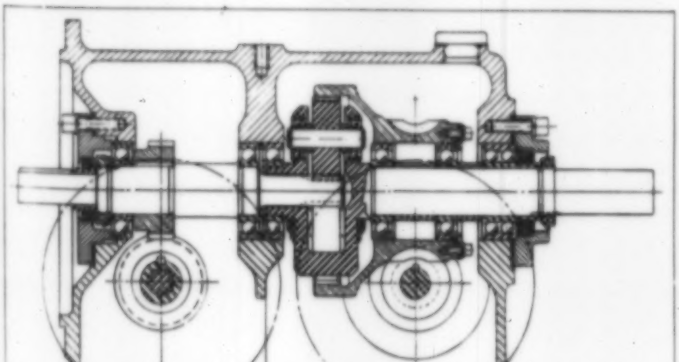
A somewhat different arrangement of operating elements has been utilized in a transmission design which employs planetary gearing to provide differential action, *Fig.* 77. These units are best suited to applications where an initial gear reduction and close control of speed down to zero are required.

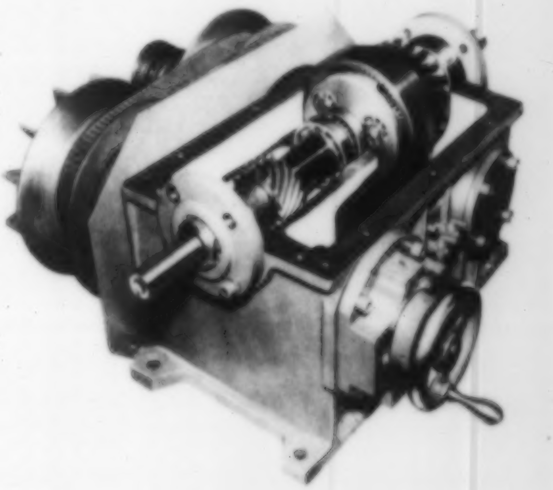
Speed adjustment is accomplished through a variable-pitch sheave system which controls the speed of the ring gear in a planetary gear set. Power enters the system through an input shaft which carries the sun gear of the planetary set at its output end. Part of the input power is diverted to the variable-pitch sheave system by means of a right-angle spiral gear arrangement and re-enters at the ring gear through right-angle worm gearing. Final drive is from the planet pinion carrier to the output shaft which is in line with the input shaft. Gear ratios in the system are established so that the speed of the output shaft is zero when the two cross shafts are operating at maximum differential speed.

Units are designed for use with standard 1800 and 1200-rpm motors with ratings from 2 to 15 hp. Maximum output speeds range from 112 to 215 rpm and all models go to zero speed. Rated torque capacities vary from 920 to 3800 lb-in., depending on unit and motor size. A reduction of from 8:1 to 10:1 from input speed to maximum output speed is produced by the gear arrangement.

Ratings are based on allowable output torque, which is constant throughout the speed range and is limited by the capacity of the gearing. Unit size is thus determined by the maximum load torque requirement. Transmission efficiency increases with output speed and for best performance, maximum speeds of the load and transmission should be matched as closely as possible.

Speed control may be accomplished manually with a handwheel, remotely by means of a reversing motor, or automatically by a cam actuating





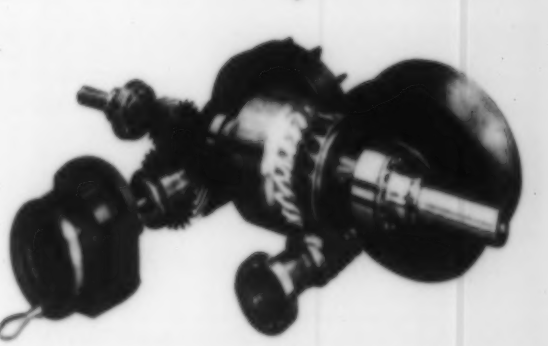
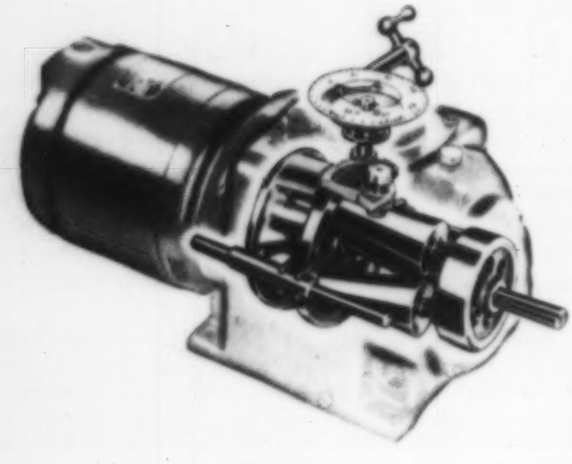
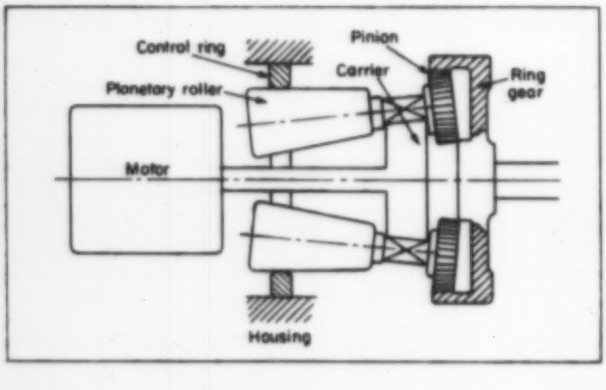


Fig. 77—Commercial differential transmission design employing planetary gearing in combination with variable-pitch V-belt sheaves for infinite-range speed adjustment. Photos, courtesy Lombard Governor Corp.

Fig. 78—Metal-traction type transmission employing planetary differential action to provide infinite-range speed adjustment. Stepless variation of output speeds is obtained by changing the position of the control ring along the tapered roller surfaces. Photo, courtesy Graham Transmissions Inc.





mechanism. Applications have been primarily on textile and similar machinery where operation is continuous over long periods of time and must not be interrupted until a complete work cycle has been completed. The comparatively light loading of the V-belt at operating speeds contributes to reliability under these duty conditions. As in the case of the bevel gear differential units, these transmissions are subject to circulating power loads and the considerations discussed previously will apply.

Planetary Metallic-Traction Systems: Differential action without the circulating power characteristic is obtained in a commercial transmission design, *Fig.* 78, which utilizes metal traction principles for speed adjustment. The arrangement is similar to that of the compound differential transmission used in the Model T Ford; tapered rollers on inclined axes and a traction control ring are analogous to the three sets of planetary pinions and contacting gears formerly used. In this system, the planet carrier is driven directly by the motor and carries the planet members which consist of a tapered roller and pinion gear on a common shaft. Rotation is imparted to the planet members by the stationary control ring which engages the tapered rollers under frictional contact. Power is delivered to the output shaft through a ring gear in mesh with the planet pinions.

Output speeds are varied by moving the control ring along the surface of the tapered rollers to change the effective diameter of the friction roll. A stepless speed variation is obtained and output speeds to zero, or in reverse, are possible. Contact loading is provided by centrifugal force at the rollers, augmented in certain cases by springs. Since the speed changing and differential gear elements are integrally mounted, circulating power flow is avoided and reaction torques are absorbed in the stationary control ring.

Capacities vary from fractional to 5 hp. Most of the models are available in two speed-range options, with output speeds varying approximately from either (1) ⅓ input speed forward through zero to 1/100 input speed reverse or (2) 1/5 input speed forward through zero to 1/5 input speed reverse. An exception is the 5-hp unit which provides speeds to zero but does not have reverse range. Standard 1800 or 1200-rpm drive motors are generally used although some of the fractional horsepower units are designed for 3600 rpm input. Lower input speeds down to 100 rpm are feasible, but capacity is reduced accordingly unless auxiliary spring loading at the rollers is

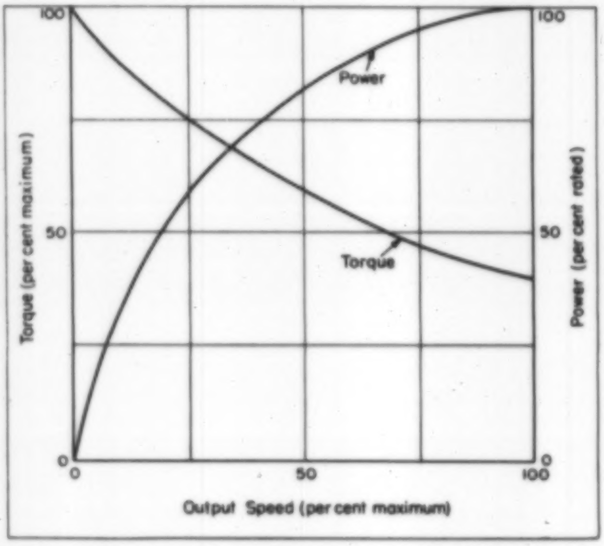


Fig. 79 — Typical performance curves for transmissions of the type shown in *Fig.* 78. Drawing, courtesy Graham Transmissions Inc.

provided. Various types of mountings and control systems for manual, remote or automatic operation are offered and units can be obtained with integral motors as well as built-in step-up or reduction gearing.

Design and operating characteristics of these transmissions parallel those of the limited-range traction units discussed previously. Units are compact and self-contained, with mechanical elements operating in oil. Operating efficiency at full load is generally around 85 per cent but varies with unit size, dropping to about 65 per cent in the under 1/6 hp capacity range. Horizontal mounting is recommended, although units may be adapted to other operating positions with minor modifications.

A unique feature of this design, as contrasted to other metal-traction systems, is the degree of inherent overload protection provided by the speed-changing mechanism. The rollers must rotate about their own axes as well as that of the planet carrier even with the output shaft stalled, minimizing the danger of damage from slippage and wear due to sudden load changes. In addition, the units can be operated in either direction of input rotation, permitting application with a reversing power source. Speed adjustment can be obtained with the transmission running or at a standstill except, in the latter case, where the rollers are spring loaded.

Typical performance curves shown in *Fig.* 79 indicate the general relationships of torque, power and speed. Permissible torque at 1/10 maximum speed is approximately twice that at maximum speed. Torque values at maximum speed range from 1.5 to 425 lb-in. but vary according to output characteristics and unit size.

Possible applications include a wide range of general purpose and special drive systems where infinite or low-range speed control and compactness are important considerations, *Figs.* 80 and 81. For greatest accuracy and sensitivity of speed control, the design arrangement should be such that the transmission is delivering maximum output speed when the load is operating at top speed. This practice is necessary to develop the full power capacity of the transmission and to distribute the speed variation over the operating length of the rollers.

An experimental transmission design developed for a power range to about ½-hp is shown in *Fig.* 82. Essentially a two-element planetary drive system, this design does not have torque feedback problems and is theoretically capable of output speeds to or near zero. The mechanism is ideally suited for constant-horsepower operation, in either direction of rotation, and the recommended range of application is for reduction service from about 15:1 to 350:1.

Mechanical arrangement is similar to that of the simple planetary gear set. Two stationary outer

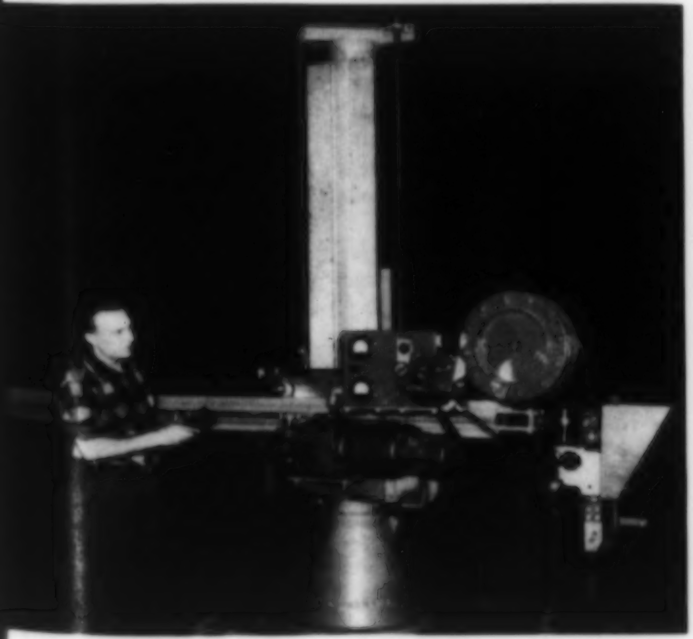


Fig. 80—Herrick welding fixture which utilizes traction type infinite-range transmission to vary ram speeds from zero to 100 in. per minute. Right-angle output gearing on the transmission drives the ram through a mating rack to provide a compact mounting. Photo, courtesy Graham Transmissions Inc.

Fig. 81—Artificial heart-lung machine using three infinite-range transmissions, shown on second tier, to control heart pumping action and blood flow during delicate heart operations. Photo, courtesy Graham Transmissions Inc.

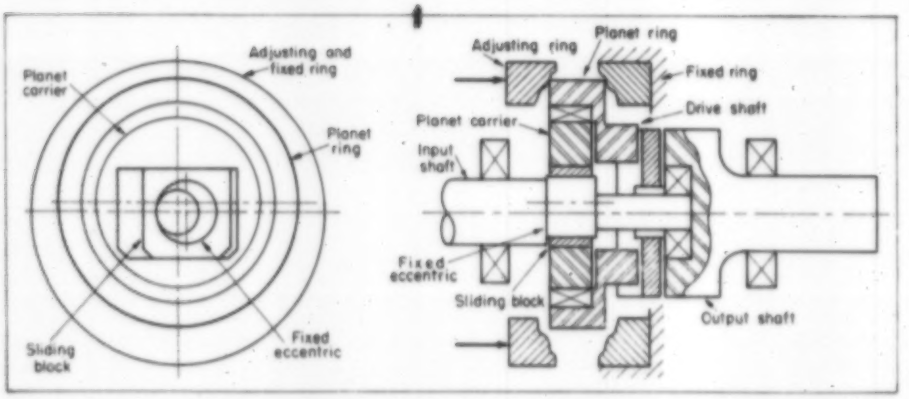


Fig. 82—Experimental high-reduction transmission of the planetary metallic-traction type. Photo, courtesy Excelermatic Inc.

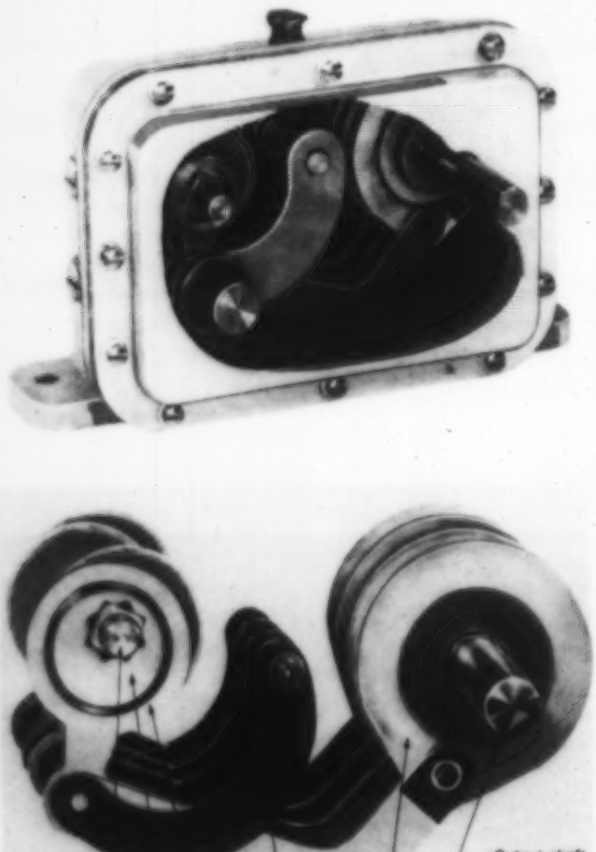


Fig. 83—Below—Variable-stroke impulse type transmission containing a series of linkages and one-way clutches for infinite-range speed adjustment. Photos, courtesy Revco Inc.

rings, one of which is adjustable axially, replace the conventional ring gear. Instead of planet pinions, there is a single planet ring which rolls on the two stationary rings, making contact at one point on each ring. Adjacent rolling surfaces of the stationary rings have special formed contours, derived mathematically from geometrical relationships. The planet ring runs freely on a bearing on the planet carrier which is the input member. Final drive is from the planet ring to the output shaft through a lug connection.

In operation, an eccentric rotating motion is imparted to the planet carrier through an off-center sliding block arrangement at the drive shaft connection. Thus, for each revolution of the carrier, the adjacent points of contact between the stationary rings and the planet ring also make one revolution, causing the planet ring to rotate backward by the distance the effective circumference of the stationary rings exceeds that of the planet ring. The rate of rotation of the planet ring about its axis approaches zero as the effective diameter of the stationary rings approaches the diameter of the planet ring. Speed is varied by moving the adjustable stationary ring back and forth to change the spread between the two rings, and, therefore, the effective diameter of roll. Design of the slot which carries the sliding block is such that the planet ring can come to a concentric position relative to the axis of the rings and the input and output shafts.

Variable-Stroke Impulse Systems: Construction of an infinite-range transmission based on the variable-stroke impulse principle (*Fig.* 69) discussed previously is shown in *Fig.* 83. Power is transmitted from the input to output shaft by means of a series of linkages which are mounted side by side and operate in phased sequence. One-way clutches are used to control direction of power transfer.

As the input shaft rotates, an oscillating motion is produced at the eccentrically mounted input links, and translated to the output shaft. Output speed is adjusted by changing the position of the control link pivot to vary the arc of travel of the output link.

Application possibilities of these transmissions are limited to the low power range; available capacities vary from a minimum of 1/30-hp to a maximum of ¾-hp. Recommended maximum input speed is 2000 rpm and any speed under the maximum can be used. Higher or nonuniform input speeds are also permissible under certain operating conditions. Normal range of stepless output speed variation is from zero to about ¼ input speed (450 rpm with 1800-rpm motor); however, reversing models which provide this full range in both directions from zero can also be obtained. Standard torque ratings are 10, 15, 20 and 100 lb-in.

Various shaft and manual, semiautomatic or automatic control arrangements are possible to meet different application and mounting requirements, *Fig*. 8 (*Part* 1). In addition, for built-in applications, the speed-changing mechanisms are available separately. Units can be operated in any position, and direction of rotation of the output shaft is not affected by changes in the direction of input rotation.

Transmissions are conservatively rated on a constant torque basis, providing a margin of protection against nominal intermittent overloads. Continued operation at any speed setting, including zero, is possible, and does not lead to excessive wear or overheating. As a result, units can be safely utilized in the zero speed position as a clutch or disconnect without shutting down the drive or changing input speed. Output speed adjustments can be made while the unit is either operating or stopped.

Output motion of these transmissions has a pulsating nature. This characteristic, which is common to systems of the variable-stroke impulse type, may or may not be of importance, depending on the application, but will usually be partially absorbed or reduced by the inertia of the load and the flexibility of the transmission elements. Successful applications vary from machine tools, *Fig*. 8, to oscillographs, *Fig*. 84, and include a variety of low-power drive systems where compactness, light weight or a wide range of speed control are important requirements.

Planetary V-Belt Systems: Differential action is obtained with variable-pitch sheaves in a V-belt drive system based on planetary motion principles, *Fig*. 85. Two "sun" sheaves and two "planetary" sheaves are employed; one of the sun sheaves is stationary and the other is mounted rigidly to, and rotates with, the output shaft. The basic arrangement is essentially the same as that of the limited-range transmission shown in *Fig*. 52 with four variable-pitch sheaves in series connected by two V-belts. In this case, the two planetary sheaves are actually the two sides of a compound sheave which has a floating, divided center flange and runs freely on a bearing

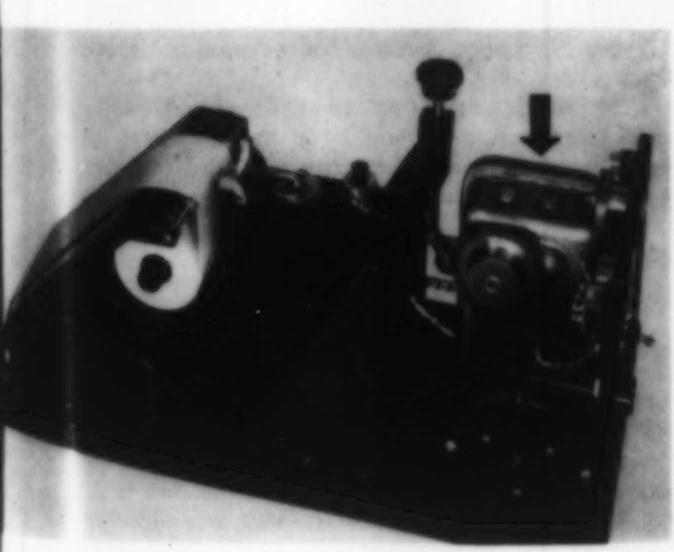


Fig. 84—Drive assembly of recording oscillograph which uses an infinite range transmission of the type shown *Fig*. 83 to vary chart speeds from zero to 5 inches per second. Input from shaded-pole motor is reduced 3:1 and output to drum is further reduced 1½:1. Photo, courtesy Revco Inc.

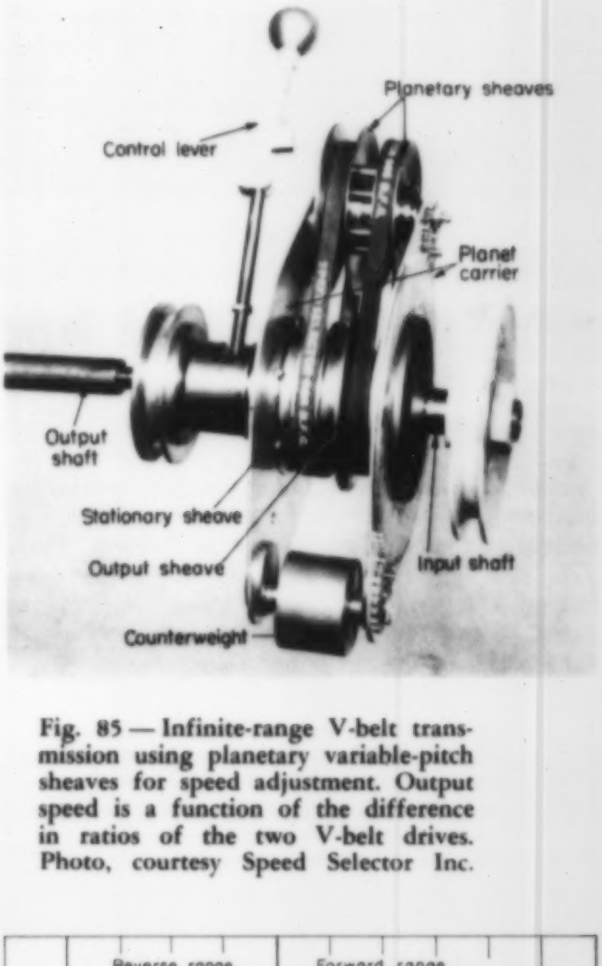


Fig. 85 — Infinite-range V-belt transmission using planetary variable-pitch sheaves for speed adjustment. Output speed is a function of the difference in ratios of the two V-belt drives. Photo, courtesy Speed Selector Inc.

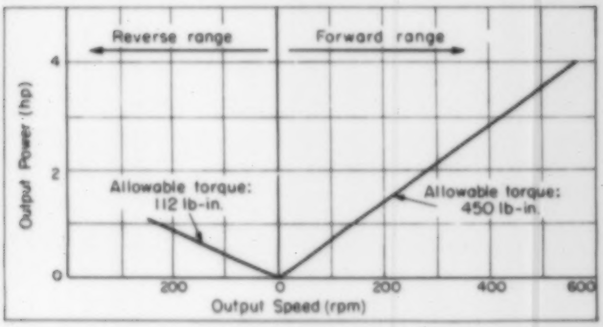


Fig. 86—Typical performance curves of a 4-hp transmission of the type shown in *Fig*. 85. Photo, courtesy Speed Selector Inc.

mounted to the planet carrier.

The planet carrier is the input member. As the planetary sheaves revolve about the central axis of the system, they also rotate about their own axis, producing a differential action that is transmitted to the output shaft. Output speed is a function of the difference in the ratios of the two V-belt drives. Speed is adjusted by varying the pitch diameter of the stationary sun sheave. This action is transmitted by belt pressure, automatically changing the pitch diameters of the three other sheaves to correspond. Output speeds to zero and in reverse can be obtained.

Capacity ratings of ½, 1, 2 and 4 hp are available. In the 4-hp unit, four planetary sheaves are used in a double arrangement and the counterweight is eliminated. Possible range of output speed variation is from 560 rpm forward through zero to about 240 rpm reverse. Maximum input speed is 1300 rpm for ½ and 1-hp units, 1040 rpm for the 2 and 4-hp sizes. However, operation at lower speeds is preferred and recommended.

Units are rated on a constant torque basis. In the forward speed range, maximum allowable torques vary from 54 to 450 lb-in. depending on unit size. For reverse speed operation, allowable torques drop to about ¼ of these values. Typical performance curves are plotted in *Fig.* 86.

When properly applied, these units offer a reliable and efficient speed-changing unit. However, the design is subject to certain limitations. Output speeds below 20 rpm are not recommended for precision operation. A reduction drive between the output shaft and the load should be used wherever possible to keep output speeds above this level. This practice is also preferred when full torque output must be utilized at speeds approaching the 20 rpm minimum. At the same time, these units will also be subject to the general considerations associated with V-belt practice.

Selection and Application Factors

General characteristics of the various mechanical methods of speed adjustment discussed in the preceding sections are summarized in *Table* 3. These data may vary for specific units within each classification but are useful for comparison of the basic systems in use today.

In practice, the drive arrangement can take a number of different forms. The complete drive assembly may, in one case, consist only of a simple speed changer and motor combination, with speed control obtained manually, *Fig.* 87. Under different conditions a fully automatic system employing special auxiliary drive and control equipment may be required to meet design and performance objectives, *Fig.* 88. Between these extremes, many drive arrangements are possible to provide varying degrees of operator convenience and speed control.

Fig. 87—Drill press in which speed is controlled manually through a simple mechanical speed changer and motor assembly. Photo, courtesy Reeves Pulley Co.

Basic considerations of power, speed and torque have been treated in *Part* 1. In the discussion to follow, attention will be given to other factors which are of importance in drive selection and application. Methods of control and "by-pass" power systems will also be analyzed.

Speed Range: For any adjustable-speed drive, the range of speed variation obtained must match the minimum and maximum speed requirements of the load. In the case of mechanical speed changing devices, recommended practice is to specify the minimum speed ratio that will still do the required job. This practice is based on the fact that, for a given size of unit, horsepower capacity and operating life increase as the speed ratio is reduced. Generally, excessive speed ratio only acts to weaken the speed-changing mechanism or may require increase in unit size and cost.

Most mechanical speed changers are designed for operation over a specific speed range and will give best performance and life under those conditions. Where load requirements deviate appreciably from this operating range, some form of auxil-

Table 3 – Mechanical Methods of Speed Adjustment[*]

System Type	Maximum Capacity (hp)	Speed Range	Method of Engagement	Speed Control	Design Features
		Stepped Speed Adjustment			
Stepped Pulleys					
Flat belt	Over 100[†]	Multiple ratios	Friction	Stationary	Low first cost
V-belt	40[†]	Multiple ratios	Friction	Stationary	Low first cost
Contact	Subfractional	Multiple ratios	Traction	Stationary	Low cost
Multispeed Gear Trains					
Selective speed transmissions	Over 100	Multiple ratios	Teeth	Stationary	Exact speed control
Selective speed drives	Fractional—15	Multiple ratios	Teeth	Stationary	Constant hp output
Epicyclic trains (planetary)	Over 100	Multiple ratios	Teeth	Motion	Auxiliary clutches and brakes necessary
		Stepless Speed Adjustment			
Variable-Pitch Sheaves					
Variable center distance	Fractional—300	1.5:1	Friction	Stationary	Standard V-belt sizes
	1½—30	3:1	Friction	Stationary	"Wide range" Q, R, W belts
	Fractional—300	1.25:1	Friction	Motion	Standard V-belt sizes
	Fractional—15	4:1	Friction	Motion	Spring-loaded flanges
Constant center distance	Fractional—300	2.25:1	Friction	Stationary	Two variable-pitch sheaves
	1½—30	9:1	Friction	Stationary	Two variable-pitch sheaves (Q, R, W belts)
	Fractional—300	1.6:1	Friction	Motion	Two variable-pitch sheaves
	Fractional—15	10:1	Friction	Motion	Two variable-pitch sheaves
Compound Sheaves	Fractional—10	10:1	Friction	Motion	Countershaft arrangement
Wheel and Disk	Subfractional	Infinite	Traction	Motion	Low torque capacity
Differential	Over 100	Infinite	Combination	Motion	Circulating power loads
Commercial Transmissions					
Reinforced belt	Fractional—87	16:1	Friction	Motion	Limited input speed
Steel belt[‡]	Fractional—25	6:1	"Chain"	Motion	Runs in oil
Multiple V-belt	1½—70	3.84:1	Friction	Motion	Input speed decreases with capacity
Compound sheave[‡]	Fractional—20	16:1	Friction	Motion	Input and output shafts in line
Wheel and disk	0.025	25:1	Metal traction	Motion	Max. output speed, 10,000 rpm
Ball and disks	Fractional—10	9:1	Metal traction	Motion	Input capacity dependent on input speed
Variable stroke	2 (approx)[§]	120:1	One-way clutches	Motion	Pulsating output; limited input speed
Variable stroke	Fractional	Infinite	One-way clutches	Motion	Pulsating output
Planetary traction	Fractional—6	5:1	Metal traction	Motion	Output speed reduction
Planetary traction[‡]	Fractional—5	Infinite	Metal traction	Motion	Output speed reduction
Differential[‡]	1½—20	Infinite	Tooth and chain	Motion	Bevel gear differential
Differential	2—15	Infinite	Tooth and friction	Motion	Planetary gear differential
Planetary V-belt	½—4	Infinite	Friction	Motion	Limited operation under 20 rpm
Commercial Drives					
V-belt	Fractional—60	10.7:1	Friction	Motion	Integral motor and V-belt transmission
Ring and cones	Fractional—5	15:1	Metal traction	Motion	All-metal version of V-belt drives

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[*] Table values are based on general design practice and are not necessarily representative of limiting values.

[†] Limited by belt speed; will vary with belt and pulley or sheave size.

[‡] Available with integral motor.

[§] Actually rated for constant torque of 200 lb-ft (max output speed = 55 rpm).

iary reduction or step-up drive should be used between the driven machine and the transmission. A good rule to follow is that the transmission should be delivering maximum speed when the load is operating at top speed.

When a reduction drive is used to "position" the output speed range of a mechanical transmission, one important limitation should be observed. The reduction should take place between the transmission and the load and not at the input side. Otherwise, the transmission may be subjected to excessive torque loads at low speeds under the design operating range.

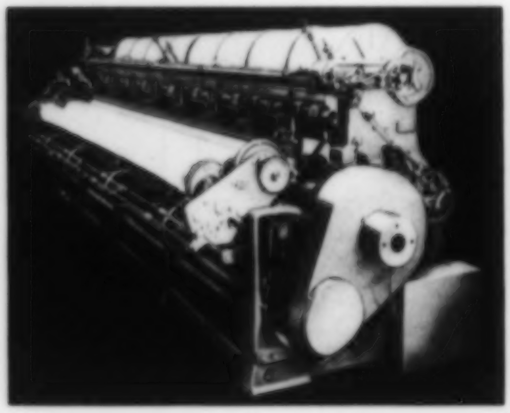
Speed Regulation: In all adjustable-speed drives based on friction principles, a certain degree of slippage which increases with torque is to be expected. Usually the effect is small and for most mechanical speed changers speed regulation will be well under 10 per cent. Smaller values of regulation, down to 0.5 per cent for some transmissions, can be obtained but will usually be reflected in the form of higher costs. For most general purpose applications, close speed regulation is not critical but may become important when speed must be controlled within narrow limits under changing load conditions. At the same time, it must be recognized that the mechanical speed-changer is only a component of the drive assembly. Speed regulation of the motor as well as any other drive elements that may affect the output characteristics must also be considered in evaluating the overall performance of the system.

Speed of Response: For mechanical methods of speed adjustment, speed of response is subject to certain natural limitations. Time must be allowed for operating elements to shift into position and for inertia effects to be overcome. As a result, mechanical units cannot be expected to equal the speeds of response possible with some of the all-electrical systems. However, response time will usually be more than adequate to match the corresponding acceleration characteristics of most driven equipment, particularly since speed changes normally involve only a small portion of the operating range.

Methods of Control: An almost endless number of control systems have been developed for use with mechanical speed-changing equipment. For the majority of applications, speed is controlled manually through a lever, handwheel or knob attachment, *Fig.* 87. Remote semiautomatic and automatic control methods in mechanical, hydraulic or electric forms are also being successfully used.

Units of the "stationary" control type are usually limited to manual operation, although remote control is often feasible. Stepped units are primarily of the stationary control type and thus are also subject to this limitation. Notable exceptions are some of the planetary gear transmissions which have been adapted to automatic control techniques. Greatest flexibility in application is offered by the motion control units which can usually be readily adapted to most control techniques presently being used.

For manual operation, handwheels, levers or knobs can be easily modified to suit different operator convenience requirements. Vernier attachments are often useful to increase accuracy of speed adjustment. Cams are occasionally employed,



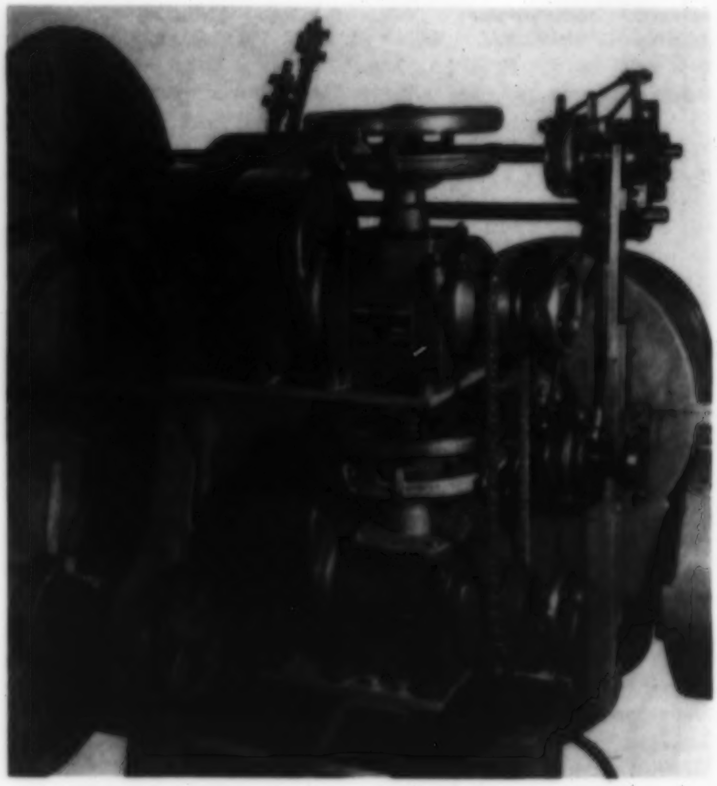


Fig. 88—Reiner mechanical beam letoff employing two adjustable-speed transmissions with built-in double reduction gearboxes for automatic control of warp-knitting machine drives. Special control system varys transmission speed to maintain uniform yarn tension during knitting operation. Photos, courtesy Graham Transmissions Inc.

mounted externally or internally, to assure a prescribed pattern of output characteristics.

Remote control is usually obtained by means of a positioning motor. A typical arrangement is shown in *Fig.* 89, where a fractional-horsepower motor is connected to the transmission control screw through reduction gearing. Output speed of the transmission is then adjusted from a push button station at a remote location.

For semiautomatic or automatic operation, control systems usually consist of three elements: (1) Sensing unit, (2) receiver and (3) drive actuator. The sensing unit detects changes in the process or machine being controlled and transmits a signal to the receiver. At the receiver, the signal is analyzed, amplified and transmitted to the actuator which adjusts the speed of the transmission accordingly.

Many variations of this servomechanism arrangement are possible. In some cases, the receiver function is eliminated and signals are transmitted directly from the sensing unit to the actuator. Systems based on electrical, hydraulic, pneumatic or mechanical principles, either alone or in combination, have all been successfully employed. Other possible variations include the various types of sensing units which can be employed with different physical quantities (motion, temperature, pressure, light, etc.) to produce the necessary actuating signals.

The time lag between error detection and correction will, in some cases, require a suitable means to collect or "pay out" the position error of the material or process. For example, in the handling of web or wire materials, floating rolls or loops of material between process steps have been used to obtain the necessary time lag. This time lag is a common characteristic of control systems of the follower type which are the ones being used principally today.

If the process and/or load requirements can be adapted to produce a signal, there should be a suitable control system that can be used with the adjustable-speed transmission. The only limitation is that the load requirements must follow a specific pattern of some type, regardless of whether the pattern is based on direct, inverse or proportional relationships. In the final analysis, performance objectives will, of course, have to be balanced against cost.

Characteristics of the different types of control systems may vary considerably. Perhaps the simplest arrangement is the program control which establishes a speed-time relationship by means of mechanically driven gear trains or cams. This type of system does not usually include a sensing or receiver function.

A more complex type employs a floating sensing element with three bands. One band is for fast operation, one for slow and the third is a central dead band. This control is subject to "hunting." A modified form of this control system utilizes an interrupter device which produces a pulsing actuator operation and reduces the hunting effect.

Another type that is being used transmits, receives, and corrects at a variable response rate. If the error is large, the actuator functions at higher speed than it would for a smaller error correction. The effect is that of a dead band con-

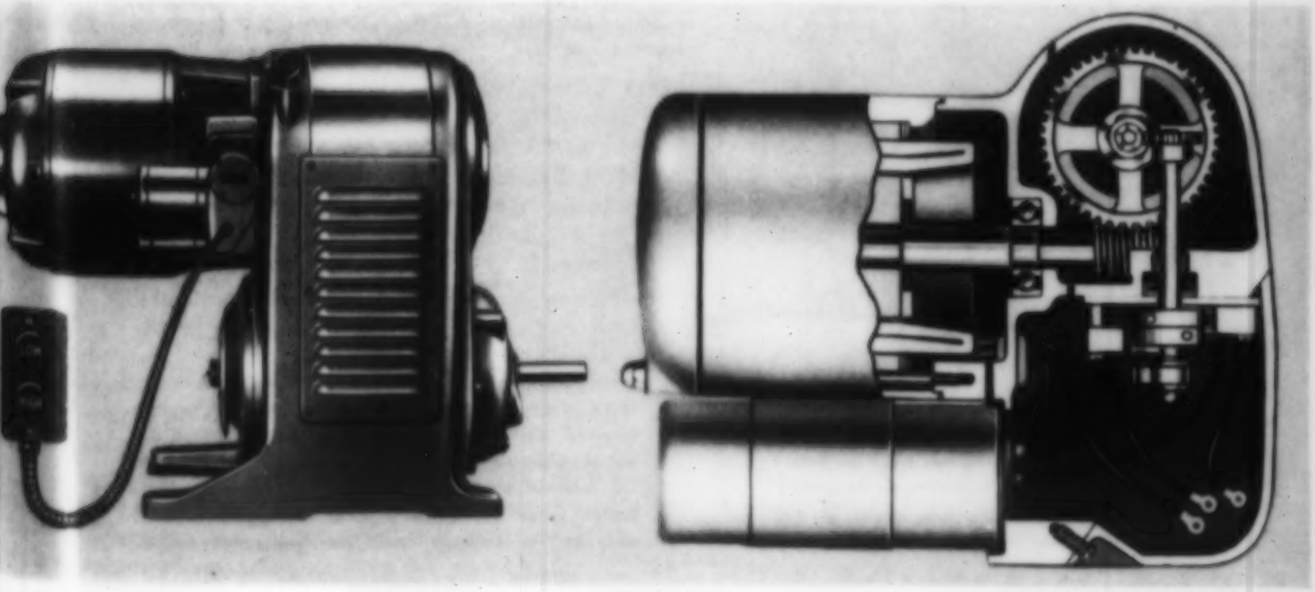


Fig. 89—Remote control system for packaged adjustable-speed drive. Positioning motor with reduction gearing is operated from a pushbutton station to vary speed of transmission. Photo, courtesy U. S. Electrical Motors Inc.

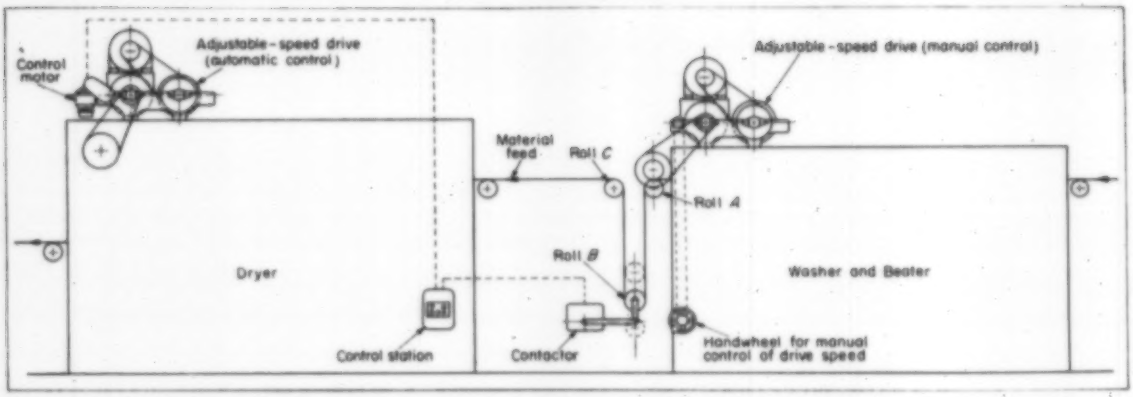
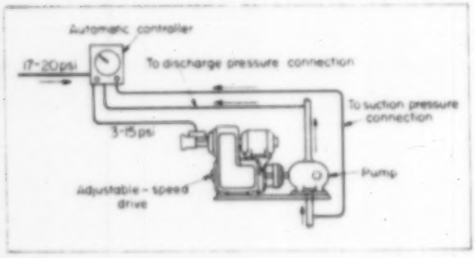
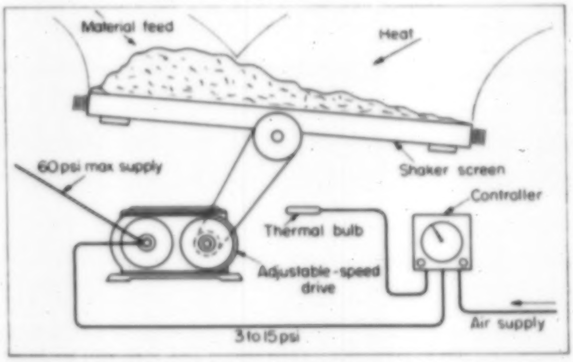

Control motor
Adjustable-speed drive (automatic control)
Adjustable-speed drive (manual control)
Material feed
Roll C
Roll A
Roll B
Dryer
Washer and Beater
Control station
Contactor
Handwheel for manual control of drive speed

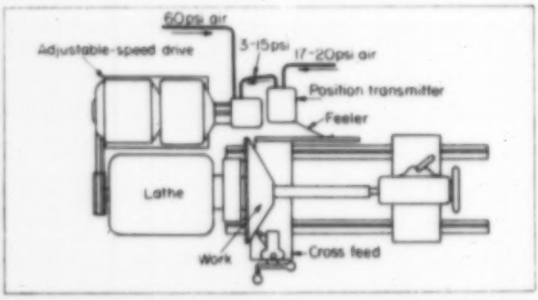
Fig. 90—Cloth processing system with automatic speed control for regulation of material feed. Variations in cloth tension move roll *B* up and down, actuating a contactor which changes the output speed of a mechanical transmission in the dryer drive assembly. Drawing, courtesy Lewellen Mfg. Co.


Automatic controller
17-20psi
To discharge pressure connection
To suction pressure connection
3-15psi
Adjustable-speed drive
Pump

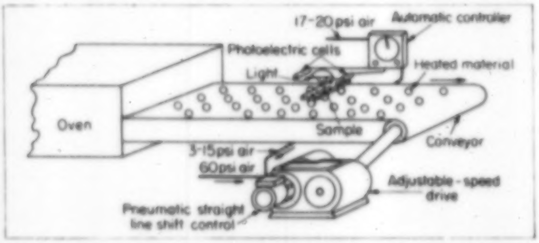
Pump drive maintains suction and discharge pressures within prescribed limits. Variations in system pressure are detected by automatic controller which pneumatically actuates adjustable-speed drive to change pump speed accordingly.


Material feed
Heat
60psi max supply
Shaker screen
Controller
Thermal bulb
Adjustable-speed drive
Air supply
3 to 15psi

Shaker-screen drive controls drying of process material. Wet or moist raw material is fed to vibrating screen and travels gradually downward. Rate of drying is detected by a thermal bulb which measures the amount of heat passing through material. Controller connected to thermal bulb pneumatically actuates adjustable-speed drive, changing rate of screen vibrations and feed of material to assure uniform drying.


60psi air
Adjustable-speed drive
3-15psi
17-20psi air
Position transmitter
Feeler
Lathe
Work
Cross feed

Lathe spindle drive provides constant cutting speed. Tool position is measured by a feeler on the position transmitter. Signals from the transmitter actuate the drive, increasing or decreasing the spindle speed as the tool moves in and out to maintain constant surface speed.


17-20psi air
Automatic controller
Photoelectric cells
Light
Heated material
Oven
Sample
Conveyor
3-15psi air
60psi air
Adjustable-speed drive
Pneumatic straight line shift control

Oven conveyor drive regulates temperature of heated material. Color of material leaving oven is picked up by photoelectric cell and compared electrically with the color of an ideal sample by the automatic controller. Speed of the conveyor is adjusted pneumatically by the controller until the two colors match.

Fig. 91—Typical automatic control systems used in processing applications. Drawings, courtesy Reeves Pulley Co.

trol. Since signal strength is proportional to the error, the error will continue to exist until signal strength is sufficient to cause the receiver to operate the actuator. If the signal control over the receiver is too sensitive, excessive hunting will result.

A typical arrangement that has been widely used in textile mills to compensate for material variations and irregularities in a cloth processing operation is shown in *Fig.* 90. A manually controlled transmission establishes the speed of material emerging from the washer and beater. The material passes over roll *A*, drops down under roll *B*, and is turned upward to pass over roll *C*. Roll *B* is a floating roll and maintains tension on the material. If the material tends to shorten, the roll will rise; if the material lengthens, the roll will drop.

Movements of the roll actuate a contactor which transmits an electrical signal to a control motor on a mechanical transmission in the dryer drive assembly. Feed of the material through the dryer is automatically reduced or increased, to maintain the position of the roll within certain prescribed limits. The weight of the roll may be readily modified to meet different tension and processing requirements.

This same system could be extended to processes involving any number of operational units. If five units were used, one would have manual control and the other four would be automatic.

Systems of this type and others suitable for a variety of different processing requirements are commercially available in horsepower capacities and speed ranges to suit almost any type of motion-control adjustable-speed drive, *Fig.* 91.

By-Pass Power Systems: Potential application possibilities are offered under certain conditions by the so-called "by-pass" power arrangements which employ a mechanical transmission of reduced capacity in combination with a differential gear train. Only a small portion of the total power is transmitted through the mechanical transmission while the rest is by-passed through the differential gear set. Thus, in a 10-hp drive, speed may be controlled by a transmission of only 1 hp capacity.

Applications are limited to small ranges of output speed variation where high accuracy and/or automatic speed control are required. This limitation is due to the circulating power characteristic which acts to increase transmission capacity as range of speed variation is increased.

In the application of these systems, torque and power relationships must be carefully analyzed to determine the most practical design arrangement. Required capacity and output speed range of the transmission will vary with the drive ratio of the differential gearing. As the drive ratio is increased, the power requirement in the transmission will decrease but the speed-range requirement will increase. A wide or infinite-range transmission will usually be required.

The two arrangements shown in *Fig.* 92, which were considered for use in a cigarette-making machine drive, illustrate the considerations involved. Power requirement is 1 hp and the range of output speed variation is 10 per cent above and below a nominal speed of 600 rpm, or from 540 to 660 rpm. Design of the drive system is based on a planetary gear differential with the ring gear driven at the mean output speed of 600 rpm. Speed of the sun gear, and the output speed of the system, are controlled by the transmission. Final drive is through the planet gears and carrier to the output shaft.

In the arrangement shown in *Fig.* 92*a*, drive ratio of the differential gearing is 3:1. To produce the desired range of output speeds (540 to 660 rpm), speed of the sun gear, and transmission, will have to vary from 360 to 840 rpm or in a ratio of 2.33:1. The power flow when the system is transmitting 1 hp is shown in *Fig.* 92*a*. If a 5:1 differential gear ratio is used, *Fig.* 92*b*, the power requirement in the transmission will be reduced to 1/6-hp but the speed range requirement will be increased from 2.33:1 to 4:1.

In the extreme case where a speed range to zero is used for the same system output requirement, the differential ratio becomes 9:1 and the power requirement drops to 1/10-hp. However, a 9:1 ratio differential is not practical. A more realistic use of the infinite-range transmission would be with the 5:1 differential, producing a 16.66 per

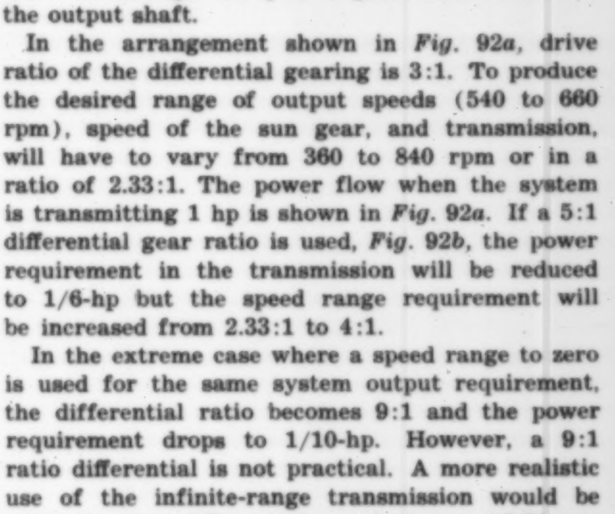

Differential gearing, 3:1
1/4 hp
Adjustable-speed transmission
Planet gear carrier
1-hp constant-speed motor
1 hp (to machine)
3/4 hp
Ring gear
Sun gear
(a)
Differential gearing, 5:1
1/6 hp
Adjustable-speed transmission
1 hp (to machine)
1-hp constant-speed motor
5/6 hp
(b)

Fig. 92—Two by-pass power arrangements showing power flow for 1-hp output with, *a*, 3:1 differential gear drive ratio and, *b*, 5:1 differential gear drive ratio. Drawings, courtesy Graham Transmissions Inc.

cent output speed variation and still reducing the power requirement to 1/6-hp.

The power delivered through the ring gear will remain constant at all output speeds. Changes in power requirements at the various output speeds must be supplied by the transmission due to the characteristics of the gear differential.

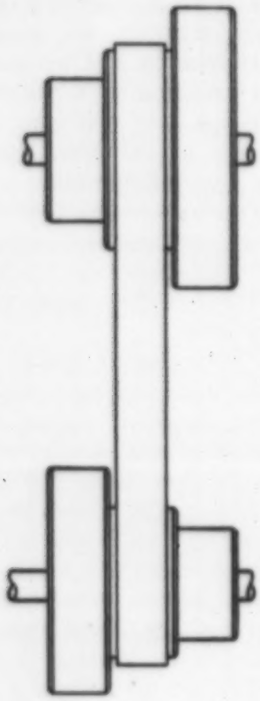
Accuracy of the transmission is multiplied by the differential ratio. In the 5:1 differential system, a speed change of 0.25-rpm at the transmission would only change the system output speed by 0.05-rpm.

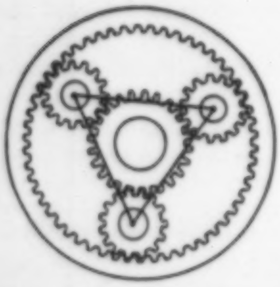
Another important consideration in the by-pass arrangements is starting conditions. The transmission must have a starting torque proportional to the full starting resistance of the load, 1/6 of it in the case of the 5:1 differential arrangement. Otherwise, the transmission will tend to be driven in reverse at high speed. Ideally, the ring-gear and sun-gear drives should be interconnected so that both elements start simultaneously.

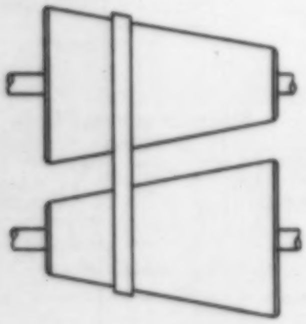
An attribute of these systems is their adaptability to automatic control techniques. The reduced transmission capacity acts to reduce the power required for control while also decreasing unit size and cost. A small control motor can thus be employed, improving acceleration and braking characteristics.

Future Articles: No attempt has been made in these articles to weigh the merits of the various types of adjustable-speed systems. A vast number of efficient hydraulic and electrical units are also available, offering output characteristics in great variety. Selection of the best drive system for a particular application will, in the final analysis, have to be judged on the basis of load requirements, performance objectives and costs.

These two articles on mechanical methods of speed adjustment represent the second in a series of basic guides on adjustable speed in design. Speed adjustment of electric motors was featured in MACHINE DESIGN, October, 1954; fluid-power systems and magnetic slip couplings will be the subjects of other basic guides to be published in future months.







Extra Copies

Copies of both parts of "Mechanical Adjustable-Speed Drives," bound as a complete pamphlet, may be obtained for $1.00 each from: Reader Service Dept., *Machine Design*, Penton Bldg., Cleveland 13, O.

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Designing
Nonstandard Spur Gears

. . . for standard cutting tools

ALTHOUGH involute gear teeth of standard proportions satisfy the great majority of designs, "nonstandard" proportions are sometimes desirable. Such need may arise because of nonstandard center distances, or because of requirements for improved surface or beam strength.

Using *standard* tooling to produce *nonstandard* gears is certainly the most convenient solution to the problem and, generally, a perfectly adequate one. However, departing from prescribed standard conditions leads to the question: What is a proper design procedure? Recommendations and information for a design approach to this problem are presented in this article. Techniques will deal with the design of those nonstandard gears that can be generated by employing standard 14½ and 20-degree full-depth involute hobs or rack cutters and pinion cutters.

Hobbing: The effects of cutting a 20-degree full depth, 10-tooth pinion at various hob offsets is shown in *Fig.* 1; it is assumed in each case an adequate amount of material is available in the blank to cut a tooth of standard height. Of course, if the hob is run too far into the blank, the tooth becomes excessively undercut and lacks in involute profile. Conversely, as the hob is withdrawn from the blank, the resulting tooth form is thicker, more pointed, and not undercut. In each case in *Fig.* 1 the hob generates an involute tooth, and each tooth flank is involute to the same base circle.

The Lewis form factor for the point of highest single tooth contact for any gear tooth may be determined graphically. However, this procedure is lengthy, and charts showing form factors for centrally loaded gear teeth may be used with good accuracy for the design of nonstandard gear teeth. The effect of varying the hob offset, *e*, on the Lewis form factor for centrally loaded teeth of gears containing various numbers of teeth is graphically depicted in *Fig.* 2. The hob offset is the distance the standard pitch line of the hob is moved radially

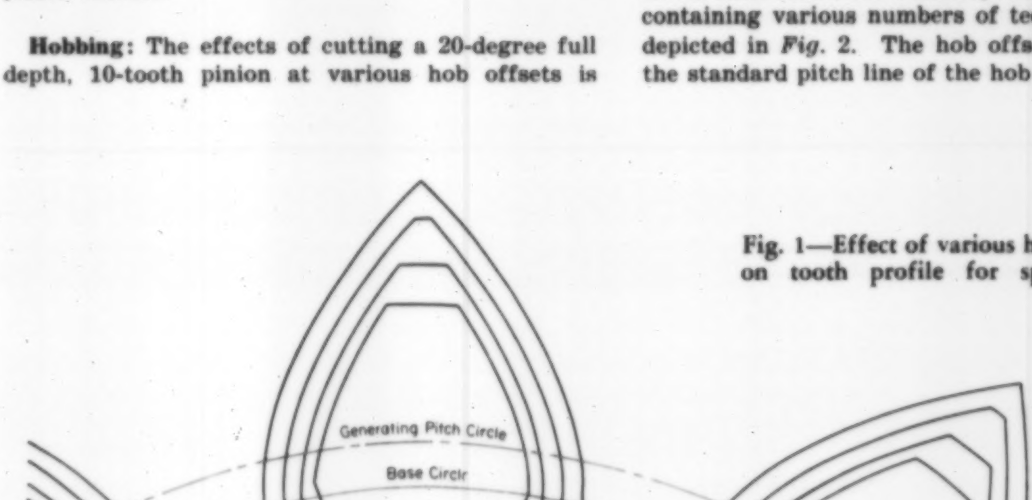
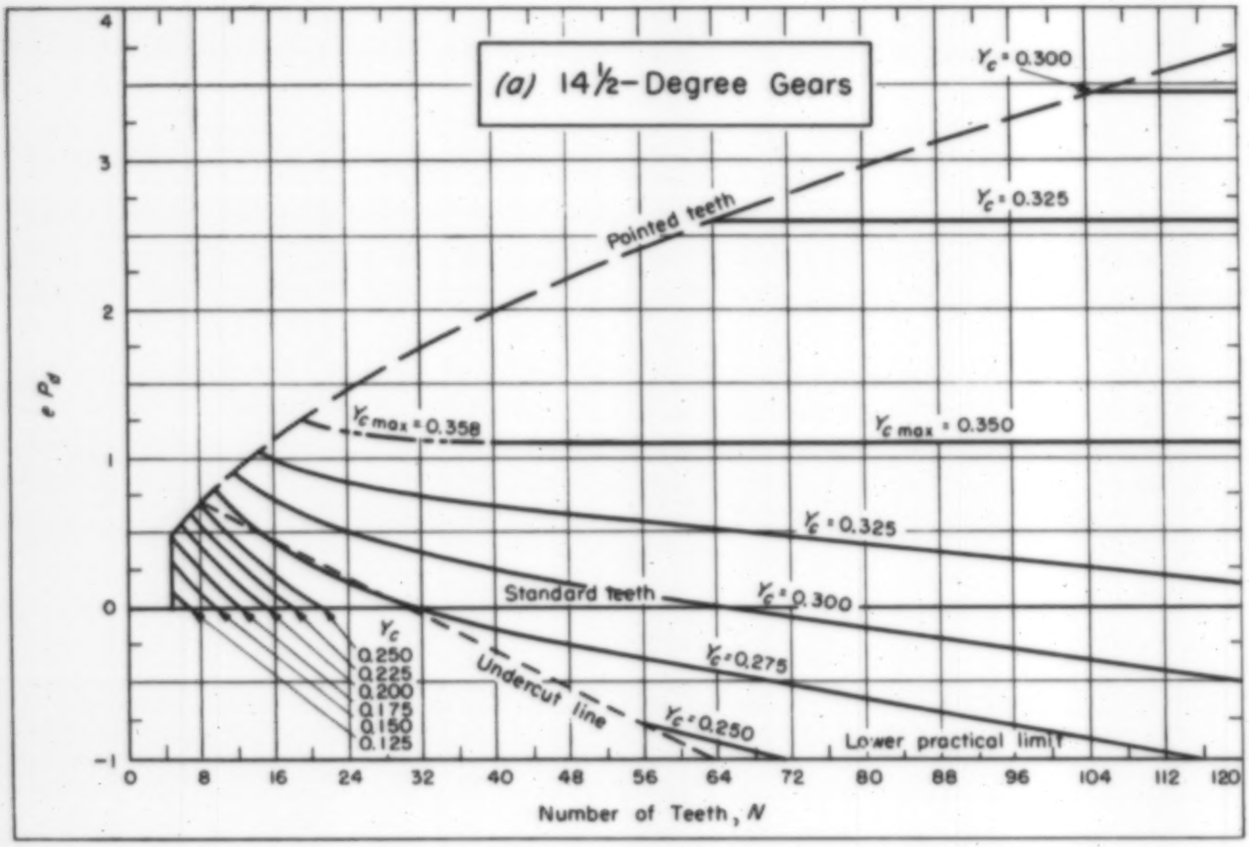
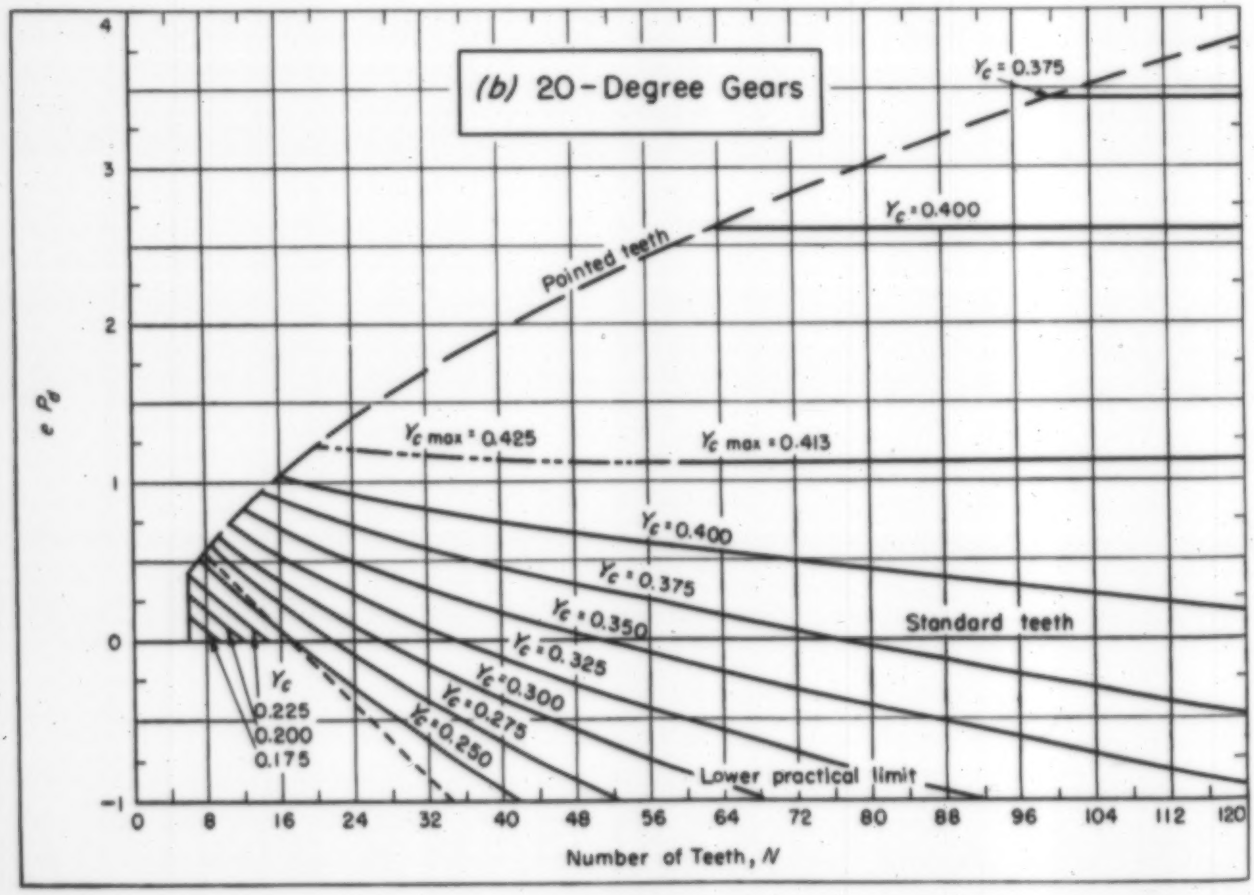


Fig. 1—Effect of various hob offsets on tooth profile for spur gears


(a) 14½-Degree Gears
Y_c = 0.300
Y_c = 0.325
Pointed teeth
$Y_{c\,max}$ = 0.358
$Y_{c\,max}$ = 0.350
Y_c = 0.325
Standard teeth
Y_c = 0.300
Y_c = 0.275
Y_c
0.250
0.225
0.200
0.175
0.150
0.125
Undercut line
Y_c = 0.250
Lower practical limit
eP_d
4
3
2
1
0
−1
0
8
16
24
32
40
48
56
64
72
80
88
96
104
112
120
Number of Teeth, N


(b) 20-Degree Gears
Y_c = 0.375
Y_c = 0.400
Pointed teeth
$Y_{c\,max}$ = 0.425
$Y_{c\,max}$ = 0.413
Y_c = 0.400
Y_c = 0.375
Standard teeth
Y_c = 0.350
Y_c = 0.325
Y_c = 0.300
Y_c = 0.275
Y_c = 0.250
Y_c
0.225
0.200
0.175
Lower practical limit
eP_d
4
3
2
1
0
−1
0
8
16
24
32
40
48
56
64
72
80
88
96
104
112
120
Number of Teeth, N

outward from the standard pitch line of the gear.

The Y_c form factors in *Fig.* 2 are all reduced by a stress concentration factor of 2. The actual stress concentration depends on tooth form and direction of loading and, in particular, on the form and surface roughness of the tooth root. The root is generated by a finite number of strokes of a generating tool and, in general, is not a smooth curve. The stress concentration may be further affected by heat treatment and gear misalignment. If the actual stress concentration factor is accurately known, the values of Y_c in *Fig.* 2 may be corrected accordingly.

The dimensionless product eP_d, hob offset times diametral pitch, which makes up the ordinates in *Fig.* 2 permits the design of gear teeth of any diametral pitch. When $eP_d = 0$, Y_c values are for standard teeth. As positive hob offset is increased, a position is eventually reached where the tooth is pointed, *Fig.* 1. Since pointed gear teeth are undesirable, hob offsets should always be less than those which will produce pointed teeth.

Teeth cut at hob offsets lying *below* the "undercut lines" in *Fig.* 2*a* and *b* will be undercut. The intersection of the undercut line and the $eP_d = 0$ line marks the minimum number of standard teeth which can be cut on a gear without undercutting. The greatest improvement in form factor by offsetting the hob occurs in gears with few teeth. For gears with a large number of teeth, the form factor increases to a maximum and then drops off. For the 14½-degree full-depth hob action, the smallest possible nonstandard pinion which is neither pointed nor undercut contains 10 teeth, whereas a standard pinion must contain 32 or more teeth if its teeth are not undercut. The smallest nonstandard pinion in the 20-degree full-depth system which is neither undercut nor pointed contains 8 teeth, while standard gears containing 18 or more teeth will not be undercut.

Pressure Angles: The standard pressure angle ϕ_s is normally either 14½ or 20 degrees. The 20-degree pressure angle should be selected unless there is a good reason for using the 14½-degree pressure angle, such as availability of tools. The 20-degree teeth have about 25 per cent greater beam strength and 15 per cent higher surface strength than 14½-degree standard pressure angle teeth of the same diametral pitch, providing the gears have an equal number of teeth.

Fig. 2—Variation in corrected Lewis form factor, Y_c, with changes in hob or rack cutter offset, e, and number of teeth, N, for: *(a)* 14½-degree full depth involute system and *(b)* 20-degree full depth involute system. Tooth load is assumed acting $1/P_d$ inches in from outside radius. Stress concentration is assumed to be 2 in all teeth

The generating pressure angle ϕ_g will be used only in connection with pinion cutters.

The running or operating pressure angle ϕ_r for a spur gear drive is indeterminate until the center distance, C, has been specified. The running pressure angle for a gear drive may then be determined from

$$\cos\phi_r = \frac{C_s \cos\phi_s}{C} = \frac{(N_P + N_G)\cos\phi_s}{2\,P_d C} \quad \text{(1)}$$

In Equation 1 the value of C is the actual center distance and C_s is the standard center distance for the given diametral pitch and total number of teeth in the drive.

Contact Ratio: The contact ratio for involute spur gears may be calculated, with one exception, from the expression

$$m_p = \frac{\sqrt{R_{oP}^2 - R_{bP}^2} + \sqrt{R_{oG}^2 - R_{bP}^2} - C\sin\phi_r}{p_b} \quad \text{(2)}$$

The formula is applicable to all standard and non-

Nomenclature

C = Actual center distance, in.
C_s = Standard center distance for the number of teeth in pinion and gear, in.
c = Clearance, in.
E = Moduli of elasticity, psi
e = Hob offset, in.
F = Face width, in.
h_t = Depth of cut, in.
K = Horsepower correction factor
K_s = Safety factor
K_t = Service factor
K_w = Dynamic load factor
m_G = Gear ratio ($m_G = N_G/N_P \geqq 1$)
m_p = Contact ratio of profiles ($m_p = Z/p_b$)
N = Number of teeth
N_c = Number of cutter teeth
n = Rotational speed, rpm
P = Power, hp
P_d = Diametral pitch
p = Circular pitch
p_b = Base pitch (normal to involute)
R = Pitch radius, in.
R_b = Base circle radius, in.
R_o = Outside radius, in.
s_b = Bending stress, psi
s_c = Surface compressive stress, psi
Z = Length of line of action, in.
Y_c = Lewis form factor including a stress concentration factor
Δ = Increase in generating center distance, pinion cutter method
Δ_c = Backlash allowance along center line, in.
ϕ_g = Generating pressure angle, deg
ϕ_r = Running or operating pressure angle, deg
ϕ_s = Standard or normal pressure angle of the hob or cutter used to generate the gear, deg

Subscripts: G denotes gear, P denotes pinion standard gear drives in which the pinion and gear are cut at values of hob offset lying between the undercut and pointing lines in *Fig.* 2. Equation 2 does not apply where there is sufficient undercutting of either the pinion or gear teeth to remove any portion of the active involute profiles of the teeth.

The base pitch, p_b, is the same for both the pinion and gear and is given by

$$p_b = \frac{\pi \cos \phi_s}{P_d} \quad (3)$$

It is important that Equations 1 and 2 be used to check the maximum and minimum contact ratios corresponding to the best and worst combinations of gear tolerances even in a standard gear design problem. A suggested minimum contact ratio is 1.2.

Preliminary Design Procedures: The preliminary design of a nonstandard gear drive is similar to that of a standard one. A convenient procedure is to determine a face width, F, for the pinion and gear by using the Hertz equation for surface compressive stress assuming the center distance and materials have been chosen. This procedure avoids the selection of number of teeth and diametral pitch until after the face width has been determined. The reasoning for this procedure is as follows: (Fig. 3)

If the center distance, C, and the gear ratio, m_G, are approximately fixed in a gear design problem, the pitch radius for the pinion is

$$R_P = \frac{C}{m_G + 1} \quad (4)$$

while for the gear

$$R_G = \frac{m_G C}{m_G + 1} \quad (5)$$

Next assume a running pressure angle, ϕ_r, equal to the selected value of the standard pressure angle, ϕ_s which is usually 20 degrees, but is still sometimes 14½ degrees. The final value of ϕ_r will always be similar to ϕ_s and will usually be slightly larger than ϕ_s. The approximate running pressure angle assumed will determine the approximate pressure line and base circles for the pinion and gear. The radius of the pinion base circle is

$$R_{bP} = R_P \cos \phi_r \quad (6)$$

and for the gear base circle

$$R_{bG} = R_G \cos \phi_r \quad (7)$$

Base circle radii determine the radii of curvature of the involute profiles of the gear teeth at their pitch point. The latter radii are the same whether there are 10 teeth or 100 teeth in the gears. The values of these radii of curvature permit the determination of face width, F, without previously selecting a diametral pitch or the number of teeth in the pinion and gear. The face width can be calculated by the expression

$$F = \frac{4.3 \times 10^4 K P (m_G + 1)^3}{C^2 s_c^2 n_P m_G \sin 2\phi_r \left(\frac{1}{E_P} + \frac{1}{E_G} \right)} \quad (8)$$

For steel Equation 8 simplifies to

$$F = \frac{6.44 \times 10^{11} K P (m_G + 1)^3}{C^2 s_c^2 n_P m_G \sin 2\phi_r} \quad (9)$$

The allowable load on a gear tooth based on surface strength is proportional to the ratio S_c^2/E for the material of the gear, while the allowable beam load is proportional to the allowable tensile endurance stress, s_b. A proposed gear design should always be checked for adequate strength in both respects.

The horsepower multiplication factor, K, in Equations 8 and 9 is given by the expression

$$K = K_s K_t K_w \quad (10)$$

The service factor K_s depends on the anticipated service life and on the ratio of peak to average

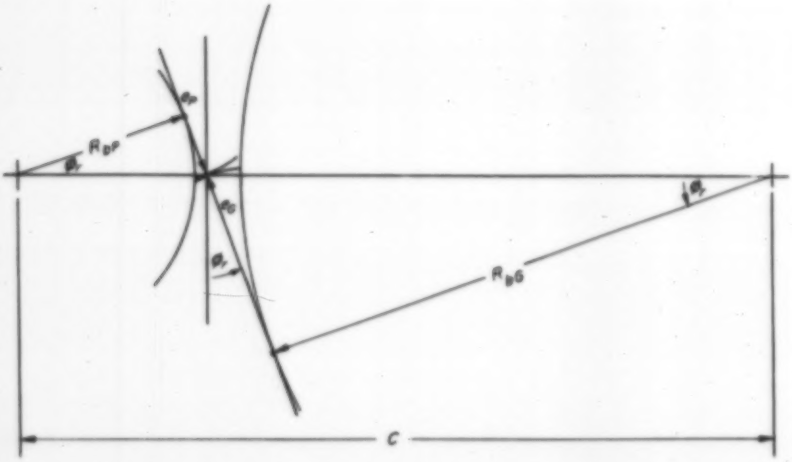


Fig. 3—Radii of curvature of pinion and gear teeth at their pitch circles. Radii are dependent on center distance, gear ratio and running pressure angle, and independent of number of teeth and diametral pitch

load. For example, certain automobile transmission gears have a low service factor because they are rarely operated at the rated horsepower of the engine. The dynamic load factor K_w depends on the accuracy of the tooth profile, the spacing of the teeth, the pitch line velocity of the gears, and, in particular, the vibration characteristics of the driving shaft, gears, gear mountings, and driven load.

After the face width has been calculated, diametral pitch and number of teeth in the pinion and the gear are selected so that each will have adequate beam strength. This means the selected face width must satisfy each of the following beam strength equations:

$$F \geqq \frac{63{,}000\, K\, P\, P_d\, (m_G + 1)}{s_{bP}\, n_P\, C\, Y_{cP}} \qquad (11)$$

and

$$F \geqq \frac{63{,}000\, K\, P\, P_d\, (m_G + 1)}{s_{bG}\, n_P\, C\, Y_{cG}} \qquad (12)$$

If the face width selected does not satisfy the Equations 11 and 12, then a wider face width, stronger materials, stronger tooth forms, or lower diametral pitches must be found. Also, the final gear design must have a satisfactory contact ratio.

Backlash: It is necessary to hob the gear teeth, or pinion and gear teeth, somewhat thinner than is kinematically ideal, in order to provide backlash for working tolerances and thermal expansion. Suggested ranges of Δ_e for various diametral pitches and generating pressure angles are given in *Table* 1. In the formulas which follow it will be assumed that all of the backlash will be provided by running the hob into the gear blank by an amount Δ_e greater than the theoretically ideal depth of cut.

Long and Short Addendum Design: To improve the beam strength of the pinion teeth, and usually to improve the contact ratio of the drive, long and short addendum gearing is used. Unfortunately the pinion teeth are strengthened at the expense of the gear teeth and the latter may or may not have an excess of strength. Also, the maximum relative sliding may become excessive if the process is carried too far. Long and short addendum gears are designed to run at the standard center distance given by

$$C_s = \frac{N_P + N_G}{2\, P_d} \qquad (13)$$

The pitch point, line of action, and pressure angle remain standard. The path of contact is changed because the pinion outside diameter is increased and the gear outside diameter is decreased.

The strength of the pinion can be increased by withdrawing the hob from its normal cutting position in the pinion blank by an amount e. Then, in order to maintain the standard center distance, the hob is run into the gear blank by an amount e greater than normal. The outside diameters of the blanks are increased and decreased accordingly. The value of e is normally just enough to prevent undercutting in the pinion. This value may be determined from *Fig*. 2 by reading the value of eP_d for the number of teeth in the pinion. In any case, the hob offset for the pinion, e_P, is equal and opposite in sign to that for the gear, e_G. The outside radius of the pinion blank is

$$R_{oP} = \frac{N_P}{2\, P_d} + \frac{1}{P_d} + e_P + \Delta_e \qquad (14)$$

while the outside radius of the gear blank is

$$R_{oG} = \frac{N_G}{2\, P_d} + \frac{1}{P_d} + e_G \qquad (15)$$

The depth of cut for both the pinion and gear is

$$h_t = \frac{2}{P_d} + c + \Delta_e \qquad (16)$$

in which c is the clearance built into the hob. The minimum value of this clearance is $0.157/P_d$ and is somewhat larger for fine pitch gears. To avoid undercutting in both the pinion and the gear, the total number of teeth in the drive should be at least 63 teeth for the 14½-degree system and at least 34 teeth for the 20-degree system.

Example Problem: Assume that a cast iron pinion and gear are to be designed by using the long and short addendum system. Suppose these gears are to transmit 10 hp between shafts located 5.333 inches apart. Pinion speed is 1170 rpm, and the gear ratio is 3:1. Assume a service factor of 1, a dynamic load factor of 1.5, and a safety factor of 1.5. Also, assume s_c is 90×10^3 psi, E is 16×10^6 psi, and 20-degree full-depth teeth are to be used.

From Equation 6, a face width of 0.95-inch is needed to satisfy surface compressive strength requirements. Next assume a diametral pitch of 6 with 16 teeth in the pinion and 48 in the gear. From

Table 1—Suggested Backlash Allowances for Spur Gears

P_d (in.)	Backlash (in.)	Range of Δ_e $\phi_s = 14\frac{1}{2}$ deg	Range of Δ_e $\phi_s = 20$ deg
1	0.025 to 0.040	0.048 to 0.077	0.034 to 0.055
1½	0.018 to 0.027	0.035 to 0.052	0.025 to 0.037
2	0.014 to 0.020	0.027 to 0.039	0.019 to 0.027
2½	0.011 to 0.016	0.021 to 0.031	0.015 to 0.022
3	0.009 to 0.014	0.017 to 0.027	0.012 to 0.019
4	0.007 to 0.011	0.014 to 0.021	0.010 to 0.015
5	0.006 to 0.009	0.012 to 0.017	0.008 to 0.012
6	0.005 to 0.008	0.010 to 0.015	0.007 to 0.011
7	0.004 to 0.007	0.008 to 0.014	0.006 to 0.010
8—9	0.004 to 0.006	0.008 to 0.012	0.005 to 0.008
10—13	0.003 to 0.005	0.006 to 0.010	0.004 to 0.007
14—32	0.002 to 0.004	0.004 to 0.008	0.003 to 0.005

Fig. 3, a eP_d value of 0.060 will prevent undercutting in the 16-tooth pinion and give a form factor, $Y_e = 0.25$. If an allowable bending stress of 14,000 psi is assumed, the necessary face width to satisfy beam strength requirements is 1.5 inches.

Extended Center Distance Design: To improve beam and surface strength of the pinion and gear, and to mesh teeth at nonstandard center distances, the extended center distance system is used. If the pinion teeth had been increased in thickness without reducing the thickness of the gear teeth in the previous example, the pinion and gear would have meshed at an extended center distance. Therefore, the extended center distance system may be used to improve the pinion teeth strength while at the same time the gear teeth remain at a standard thickness or at increased thickness.

If the values of e_P and e_G have been selected to provide an adequate form factor for the pinion and gear teeth, then ϕ_r may be determined from the expression

$$\text{inv}\ \phi_r = \frac{2\,P_d\,(e_P + e_G)\tan\phi_s}{N_P + N_G} + \text{inv}\ \phi_s \quad \text{(17)}$$

Therefore, the center distance at which the gear and pinion will run when the extended center distance system is employed is

$$C = \frac{(N_P + N_G)\cos\phi_s}{2\,P_d\cos\phi_r} \quad \text{(18)}$$

The outside radius of the pinion is

$$R_{oP} = C - \frac{N_G}{2\,P_d} - e_G + \frac{1}{P_d} + \Delta_s \quad \text{(19)}$$

while the outside radius of the gear is

$$R_{oG} = C - \frac{N_P}{2\,P_d} - e_p + \frac{1}{P_d} \quad \text{(20)}$$

Depth of cut is given by the expression

$$h_t = R_{oP} + R_{oG} - C + c \quad \text{(21)}$$

If a pinion and gear must be designed to mesh at a center distance which cannot be met by using standard teeth, design the pinion and gear to mesh at the nearest standard center distance just smaller than the required center distance. Then use the extended center distance equations to increase the thickness of the gear and pinion teeth until these teeth mesh at the required center distance.

The running pressure angle is determined from the following expression

$$\cos\phi_r = \frac{(N_P + N_G)\cos\phi_s}{2\,P_d\,C} \quad \text{(22)}$$

The sum of the hob offsets for the pinion and gear may be determined from

$$e_P + e_G = \frac{(N_P + N_G)(\text{inv}\ \phi_r - \text{inv}\ \phi_s)}{2\,P_d\tan\phi_s} \quad \text{(23)}$$

This equation gives only the sum of e_P and e_G. Choose the actual values to provide the pinion and gear teeth with satisfactory beam and surface strength, and adequate contact ratio by using *Fig.* 2 and Equation 2. *Fig.* 2 will help avoid undercut or pointed teeth. If there is no scoring problem with the teeth, choose e_P and e_G to give equal beam strength to the pinion and gear teeth. If the teeth are heavily loaded, it may be more desirable to make sure that e_P and e_G are selected so that beam strength of the pinion and gear teeth are adequate, and the PVT or scoring index is minimized.

Rack Cutters: The previous equations are applicable to gear teeth generated either by hobbing or by rack-type cutters.

Pinion Cutters: Since there are a number of forms of pinion cutters, no attempt has been made to devise charts showing the variations in tooth form factor with pinion cutter offset. However, using the method which follows, *Fig.* 2 may be employed to design nonstandard gears with good accuracy. The action of a pinion cutter produces a somewhat different root trochoid or undercutting action than a hob. However, since the pinion cutter has in general less tendency to cause undercutting than a hob, the form factors given by *Fig.* 2 will be on the safe side.

When gears are designed to be generated with a pinion cutter, assume that the gears are to be cut by a hob of the same standard pressure angle and diametral pitch as the actual pinion cutter to be used. The gears may be either the long and short addendum or extended center types. Proceed with the design up to the point of determining e_P and e_G by using *Fig.* 2. The values of e_P and e_G are then "dummy" hob offsets which serve only to define the involute profiles of the pinion and gear teeth. The problem is to determine pinion cutter settings which will generate pinion and

A Short Table of the Involute Function

Degrees	+.0 deg	+0.2 deg	+0.4 deg	+0.6 deg	+0.8 deg
14	0.00488	0.00520	0.00543	0.00566	0.00590
15	0.00615	0.00640	0.00667	0.00694	0.00721
16	0.00750	0.00779	0.00809	0.00839	0.00870
17	0.00902	0.00935	0.00969	0.01004	0.01039
18	0.01076	0.01113	0.01142	0.01191	0.01231
19	0.01272	0.01314	0.01357	0.01400	0.01444
20	0.01490	0.01537	0.01585	0.01634	0.01683
21	0.01734	0.01786	0.01840	0.01894	0.01949
22	0.02006	0.02063	0.02122	0.02182	0.02242
23	0.02304	0.02368	0.02433	0.02499	0.02566
24	0.02635	0.02705	0.02776	0.02849	0.02922
25	0.02998	0.03074	0.03152	0.03232	0.03313
26	0.03394	0.03478	0.03563	0.03650	0.03739
27	0.03829	0.03920	0.04013	0.04108	0.04204
28	0.04302	0.04402	0.04503	0.04606	0.04710
29	0.04816	0.04924	0.05034	0.05146	0.05260

Involute 14½=0.00554484; Involute 20=0.01490438 gear teeth of the same tooth thicknesses and involute characteristics as those which would be generated by a hob run at offsets e_P and e_G. Assuming that the pinion cutter has N_c teeth, the generating pressure angle for the pinion, ϕ_{gP}, is given by

$$\text{inv } \phi_{gP} = \frac{2\, e_P\, P_d \tan \phi_s}{N_P + N_c} + \text{inv } \phi_s \qquad (24)$$

Next determine the increase in the standard pinion cutter to pinion blank center distance, Δ_P, by the expression

$$\Delta_P = \frac{(N_P + N_c) \cos \phi_s}{2\, P_d \cos \phi_{gP}} - 1 \qquad (25)$$

In the same manner the generating pressure angle for the gear is given by

$$\text{inv } \phi_{gG} = \frac{2\, P_d\, (e_G - \Delta_c) \tan \phi_s}{N_G + N_c} + \text{inv } \phi_s \qquad (26)$$

Therefore, the increase in generating center distance for the gear is

$$\Delta_G = \frac{(N_G + N_c) \cos \phi_s}{2\, P_d \cos \phi_{gG}} - 1 \qquad (27)$$

The equations for the outside radii for the pinion and gear to be generated with a pinion cutter are

$$R_{oP} = C - \frac{N_G}{2\, P_d} + \frac{1}{P_d} - \Delta_G \qquad (28)$$

and

$$R_{oG} = C - \frac{N_P}{2\, P_d} + \frac{1}{P_d} - \Delta_P \qquad (29)$$

Which gives a depth of cut

$$h_t = R_{oP} + R_{oG} - C + c \qquad (30)$$

Tooth Wear: To minimize tooth scoring it is common to limit the maximum PVT values in a gear design to some safe maximum value. The PVT value at any point on the path of contact of a pinion and gear tooth is the product of surface contact pressure, relative sliding velocity, and distance from the pitch point. Of course, this product may be minimized by reducing each of the terms in the product as far as possible.

The relationship between contact stress, face width, and running pressure angle is

$$s_c \propto \sqrt{\frac{1}{F \sin 2\, \phi_r}} \qquad (31)$$

Obviously, the best way to reduce surface compressive stress is to increase gear face width, running pressure angle of the drive, or contact ratio to increase the percentage of time the two pairs of teeth are in contact.

For a given center distance, the most effective way to decrease relative sliding velocity is to increase the diametral pitch along with the relative number of teeth in the pinion and gear proportionally. That is, doubling the diametral pitch and the numbers of teeth in the pinion and gear will reduce the maximum relative sliding velocity by approximately 50 per cent. By doubling the diametral pitch and going to nonstandard teeth, a reduction of more than 50 per cent in the maximum relative sliding velocity may often be achieved. Increasing the diametral pitch will also raise the contact ratio of the drive. Contact ratio and relative sliding velocity do not go hand in hand. High contact ratios are undesirable only when they are achieved at the expense of excessive relative sliding velocities. Increased contact ratio can be attained with a reduction in relative sliding velocity.

Tooth Layout: The involute portions of a standard or nonstandard tooth profile can readily be drawn by calculating points on the involute and drawing in the curve. The root of the tooth can be calculated, but graphical methods are usually used. A photomechanical generating device was employed to prepare the large number of tooth profiles which were used to compile the data for *Fig.* 2.

Final Design Checks: The following are some of the procedures which may be used for checking nonstandard involute spur gears:

1. *Meshing with a standard rack*: The distance from the center of a spur gear to the pitch line of a standard rack in mesh with it is

$$C_r = \frac{N_G}{2\, P_d} + e_G - \Delta_c \qquad (32)$$

2. *Meshing with a standard gear*: The distance from the center of a nonstandard gear to the center of a standard gear used for checking purposes must be computed in two steps. First the running pressure angle at which the two gears should mesh tightly together is calculated from

$$\text{inv } \phi_r = \frac{2\, P_d \tan \phi_s\, (e_G - \Delta_c)}{N_G + N_{sG}} + \text{inv } \phi_s \qquad (33)$$

Then the center distance for the nonstandard and master gear is obtained from

$$C_{sG} = \frac{\cos \phi_s\, (N_G + N_{sG})}{2\, P_d \cos \phi_r} \qquad (34)$$

3. *Using an optical comparator*: It is often convenient to inspect gear teeth by comparing their profiles with a master template using an optical comparator. The master template may be made analytically, graphically, or photomechanically.

4. *Inspecting after assembly*: All of the preceding inspection procedures indicate how well a gear has been made. One qualitative test which shows how well gears have been generated and also gives an indication of the accuracy of mounting of the gears is to coat the gear mesh with a slow-drying paint. The gears are then run briefly under some load. The displacement of the paint gives a visual indication of the combined accuracy of the gears and of their mountings.

DESIGN ABSTRACTS

Cooling Hydraulic Circuits

By D. W. Retzinger
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FORCED convection occurs in many heating and cooling systems, such as in the transfer of heat from engine-jacket water to the air through the radiator in an automobile. When circulation of the fluids is caused by fan, blowers, pumps or any means other than by variation of density, the transfer of heat is said to be made by forced convection.

Transfer of heat by forced convection depends on the velocity of the fluids over the surface through which heat is conducted, on the shape of the surface, on the area through which heat is conducted, and on various properties of the fluid, as well as the temperature difference. Not over 2 or 3 hp can be removed at acceptable temperatures from an ordinary industrial hydraulic circuit by means other than forced convection.

The amount of heat to be removed from the hydraulic circuit depends on the horsepower input to the circuit and normally cannot be more than this. However, the hydraulic system may be so located as to pick up heat from an external source. If this can be avoided, then the amount of heat to be removed will depend on the cycle of operation, the overall efficiency of the pump, and amount of resistance in the circuit.

Heat Removal Equipment: Forced-convection heat-removal equipment includes transfer surface of the air-to-oil as well as water-to-oil type.

Performance of oil-to-air heat transfer equipment, including dry-air and unit oil coolers, is affected by fin size and spacing, tube type, size and spacing, turbulence promoters on the tube or fin side and fluid velocities. Since the amount of heat transferred from the inside of a tube has to be exactly equal to the amount transferred from the outside of the tube, it is evident that the area multiplied by the heat-transfer rate by the temperature difference inside the tube has to be equal to the area multiplied by heat-transfer rate by the temperature difference outside the tube.

In oil-to-water heat-transfer equipment such as a shell-and-tube heat exchanger, usually containing all prime surface, this balance is fairly easy to maintain. The greatest overall heat-transfer coefficient is normally obtained for any given shell-and-tube velocity without the use of turbulators in the tubes.

Air Cooling: In equipment where air is used as the cooling fluid because of low thermal conductivity, specific heat and other properties, *Fig.* 1, the heat-transfer coefficient external to the tubes is low. In order to maintain a maximum balance between the heat transferred inside the tubes to that transferred from the outside of the tubes (that is, to remove as much heat from the outside of the tube as can be transferred to the tube by the hydraulic oil), fins are attached to the tube. This is done so that, even though the heat-transfer coefficient external to the tube between the air and the tube is low, because of the addition of fins the actual heat transfer is increased, both inside and outside.

In addition to providing extra surface outside of the tube, the fin itself helps to create turbulence in the air flowing over the tube. Adding fins to the tubes increases the external surface above what is necessary to remove the heat transferred from the oil to the inside of the tube. In other words, the heat transfer coefficient inside the tube becomes the bottle-neck. A maximum balance no longer exists. Therefore, turbulence promoters are added to the inside of the tube. The overall effect of added fins and turbulators is an increase in the heat transferred for a given square foot of surface, plus the added surface which means more heat transfer in a given volume of space.

A practical limit is reached in the addition of fins, dictated by the allowable pressure drop on the air side and the limit of the increase in the heat-transfer coefficient on the oil side. Beyond this limit the added amount of heat transfer per square foot of fin surface decreases quite rapidly.

Water Cooling: In the use of the shell-and-tube heat exchangers for hydraulic fluid cooling, normally the flow of oil is external to the tubes, *Fig.* 2. The tubes are usually spaced on triangular centers, which helps to promote turbulence. Baffles direct the flow of fluid at right angles to the tubes, and baffle spacing is determined by the allowable pressure drop and velocity desired.

Cooling water usually flows through the tubes. Because water has a heat-transfer rate of from four to five times that of oil at the same velocity, turbulators on the water side are not necessary unless exceedingly low water velocities exist.

An increase in heat-transfer coefficient can be accomplished by increasing the number of passes the water has to make through the exchanger, which increases the velocity through the exchanger for any given water quantity. However, an increase in the number of passes usually means a decrease in surface for any given shell diameter because the pass baffles take space in the shell. Then too, because of temperature differences, a multipass exchanger may not be possible. Fouling resistances, which are added as a factor of safety so that the surface will perform satisfactorily after many hours of use, have been set up by the Tubular Exchange Manufacturers Association, and are usually adhered to in the design of shell-and-tube heat exchangers. However, many designers of various heat-transfer surfaces work with clean heat-transfer coefficients and then add a percentage of excess surface to take care of any fouling.

Normally, metal resistance to the transfer of heat does not become important and is usually disregarded in figuring the overall heat-transfer coefficient. However, should the tube wall be heavy-gage, or the transfer surface be of low thermal conductivity such as stainless steel or Monel metal, it is advantageous to check the resistance of the tube wall in the overall heat-transfer coefficient.

Direction of Flow: Counter-flow is obtained in an exchanger where fluids flow in opposite directions to each other the entire time heat is being transferred. Parallel flow exists when the two fluid streams flow in the same direction through an exchanger, whereas cross-flow exists when one fluid flows at right angles to the other.

Many shell-and-tube heat exchangers are made with multiple passes on both the shell and tube side, although the more common multiple-pass exchangers are single pass on the shell side and two or more passes on the tube side. Since the greatest mean temperature difference exists in true counter-flow, it is an advantage, in order to obtain the maximum transfer of heat for the temperature levels which are available, to pipe the heat-transfer equipment always in counter-flow.

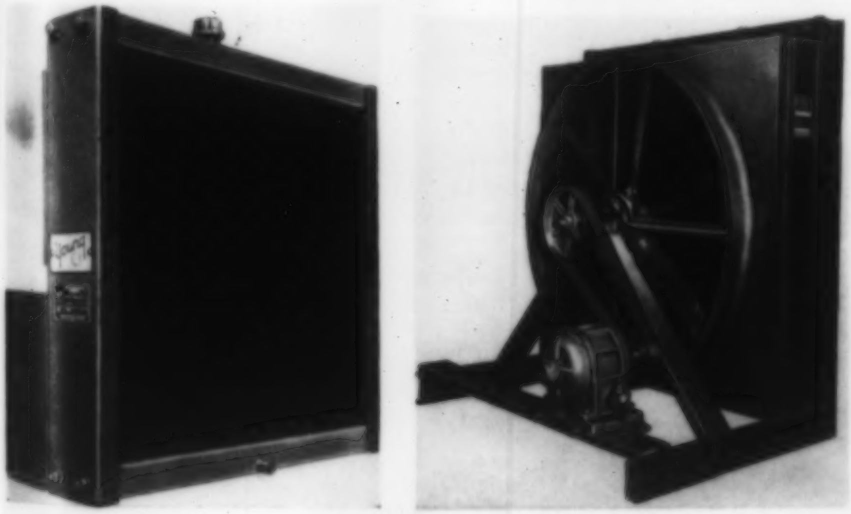

Fig. 1—Dry-air type hydraulic coolers consist of a core section enclosed in a case with a fan and fan shroud, motor, belts and sheaves

Equipment Selection: Examples of equipment which can be used in cooling hydraulic systems are: shell-and-tube heat exchangers, which would be water-to-oil heat transfer; dry-air type coolers, which would be air-to-oil heat transfer; or the evaporative cooler, water-to-oil and evaporation of part of the water for cooling of the remainder by counter-flow of air. The type of cooling equipment to be purchased should be determined, first of all, on the temperature levels involved and practical for the application; second, on the availability of the cooling system; third, on the flexibility desired; and fourth, on cost of operation and first cost.

Evaporative Cooler: An evaporative cooler is made up of a coil section through which the oil would be circulated; over this coil section water is sprayed from a spray tree, while air is drawn up from the bottom, counter-flow to the water flowing down over the coil, and blown out of the top. Part of the water in passing through the air stream evaporates, thereby cooling the remainder of the water. The water temperature will approach the wet-bulb temperature and, therefore, the oil will approach the wet-bulb temperature.

In addition to the coil section with the spray tree, a blower section handles the air, and a sump, together with a water circulating pump, handles the water.

The evaporative cooler will evaporate approximately 1 pound of water for every 1000 Btu removed. This is generally about 10 per cent of the water used in an ordinary shell-and-tube heat exchanger for the same cooling. The advantage of the evaporative cooler is that cooling depends on the wet-bulb temperature, which is usually 20 to 50 degrees less than the dry-bulb temperature.

Disadvantage is that the water has to be piped to the evaporative cooler, and a corrosion problem exists. Also, the water has to be drained from the system when the dry-bulb temperature is below 32 F to prevent it from freezing. When the water is drained, the cooler can be used as a dry-air type cooler.

Dry-Air Cooler: In many locations water is not readily available, is too expensive for hydraulic fluid cooling, or the installation on which the cooler performs is mobile. In these instances, unit oil coolers, which are dry-air type coolers, are used.

The dry-air type cooler consists of a core section having either round or flat tubes, depending on the working pressure, with fins mechanically or metallurgically bonded to them, over which air is blown by means of a fan located near the coil surface, *Fig*. 1. The oil is circulated through the tubes. Turbulators are included in the tubes to promote transfer of heat. The dry-air cooler would not be subject to freezing, there would be no water connections required, nor would there be the corrosion problem connected with water.

The unit oil cooler is suitable for application where the oil temperature does not approach the air temperature closer than 10 degrees and, therefore, oil temperatures are usually limited to a minimum of about 130 F entering the cooler. Control of the unit oil cooler is by use of a temperature control bulb located in the oil with an on-off switch for fan operation.

The unit oil cooler requires relatively simple piping, and because water is not used, there is no chance of it entering the hydraulic system. The unit oil cooler is not used as widely as the shell-and-tube heat exchanger because the oil temperature has to be maintained higher than if water cooling were used. This is because design conditions frequently dictate an ambient air temperature of 100

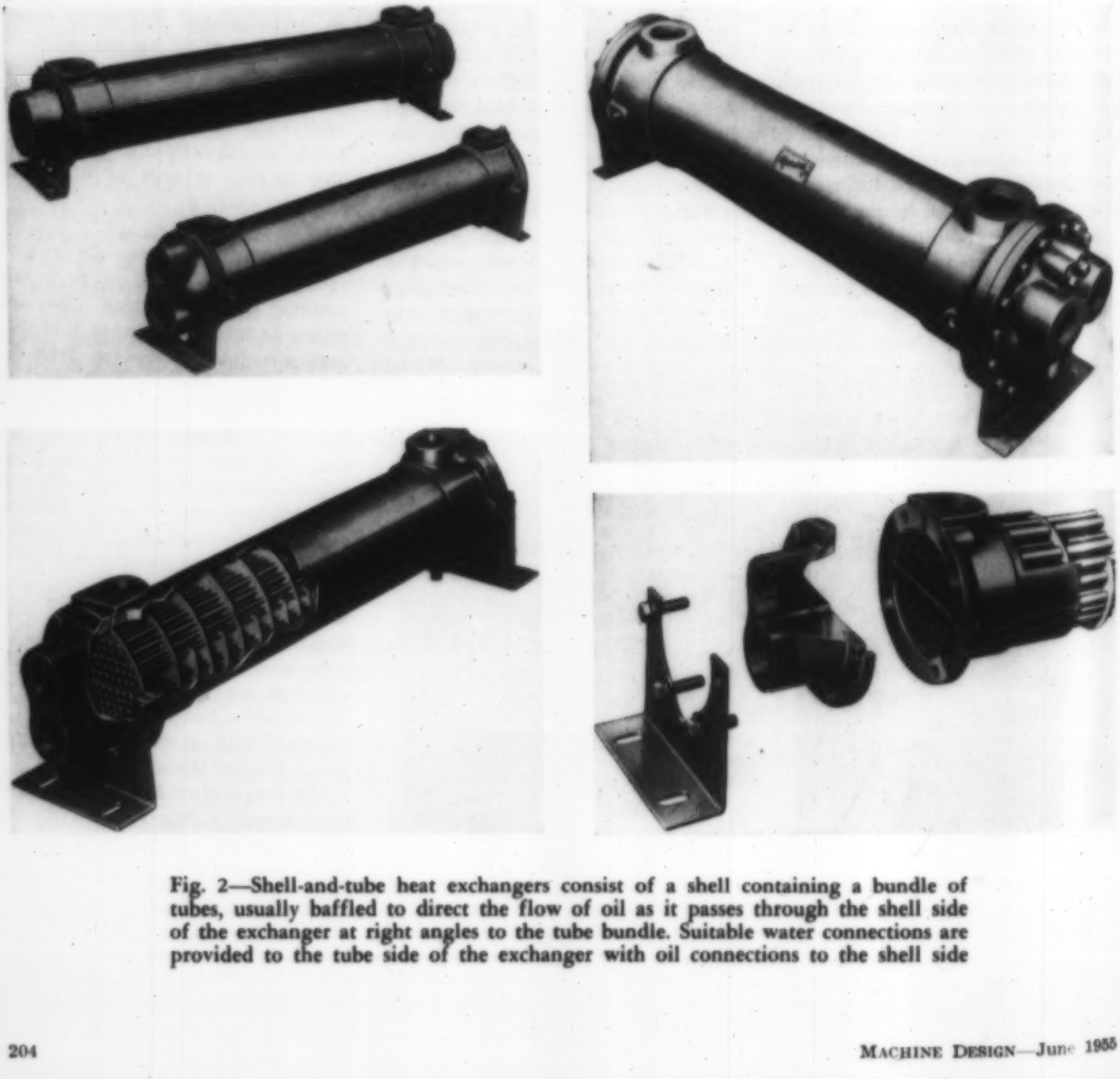

Fig. 2—Shell-and-tube heat exchangers consist of a shell containing a bundle of tubes, usually baffled to direct the flow of oil as it passes through the shell side of the exchanger at right angles to the tube bundle. Suitable water connections are provided to the tube side of the exchanger with oil connections to the shell side

F or more, and in order to maintain an oil temperature entering the exchanger of less than 130 F, excessive surface would be required.

Shell-and-Tube Heat Exchanger: A third piece of cooling apparatus is the shell-and-tube heat exchanger, with water to the exchanger furnished from a well, the city supply, a cooling tower or an evaporative cooler. Depending on the water temperature available, the shell-and-tube heat exchanger represents the least first cost with the highest operating cost. Corrosion is a problem when water is used. However, the low temperature to which the oil can be cooled, as well as the compactness of the equipment and the possibility of placing this equipment in almost any desired location, make this type of cooling equipment attractive.

The shell-and-tube exchanger consists of a shell into which is assembled a bundle of tubes, usually baffled to direct the flow of oil as it passes through the shell side of the exchanger at right angles to the tube bundle, *Fig.* 2. Suitable water connections are provided to the tube side of the exchanger, with oil connections to the shell side of the exchanger.

Tubes are fixed to the tube sheet either by brazing or rolling, and the tube bundles can be removable or fixed. The tube bundle on an individual cooling system usually is a fixed bundle because of the lower first cost. A removable bundle would be used where the shell side of the exchanger may be fouled sufficiently so that the bundle will have to be removed to be cleaned. In a fixed or removable tube-bundle exchanger the tubes can ordinarily be cleaned on the tube side by brushing, or with a solvent, without removal of the bundle from the shell.

A single-pass exchanger should be connected in counter-flow so that the water will flow in opposite directions through the exchanger to that taken by the oil. Where a multipass exchanger is used, the oil should enter the exchanger at the same end at which the water enters and leaves.

The performance of a shell-and-tube heat exchanger is determined by the area or surface in the exchanger. Generally, the greater the surface, the more heat the exchanger will transfer. Other than this, tube spacing, tube diameter, baffle spacing and clearance between baffle and tubes and baffle and shell can all add or detract from the performance of an exchanger with a given amount of surface, by from 10 to 25 per cent.

Water is generally supplied to the tube side of the exchanger in an amount sufficient to do the cooling required. A water-regulating valve should always be used to insure uniform oil temperature regardless of water temperature and to conserve water. In hydraulic systems a 2 or 4-pass exchanger is generally desirable. However, the criterion for pass arrangement is the quantity of cooling water available and the approach of the oil temperature to the water temperature. In most systems the difference between the oil and water temperatures is great enough so that a multipass exchanger can be used. However, in an application where the entering cooling water temperature approaches the entering oil temperature by 10 degrees or less, a multipass exchanger would require excessive surface or would not perform at all, but a single-pass counter-flow exchanger would transfer the heat satisfactorily.

Pressure drop through the shell side of the exchanger is, in many instances, important and usually should be limited to from 10 to 15 psi. Pressure drop through the shell side of the exchanger depends upon the length of the exchanger, velocity of the oil through the exchanger, tube size and spacing, and baffle spacing and baffle cut. Generally speaking, where the baffles are spaced 3 to 5 per shell diameter, the baffle cut could be approximately 20 per cent. With a baffle spacing of one or less per shell diameter, the baffle cut can be increased to 35 to 45 per cent. This applies to segmental type baffles where the baffle cut is the per cent open area.

Shell-and-tube heat exchangers are probably the most widely used equipment for hydraulic-fluid cooling. Their compactness, relatively low cost, standardization, availability and reliability account for this.

The exchanger has to be made of material not corroded by water. Most exchangers for industrial hydraulic-fluid cooling are built of copper-base alloys. Exchangers of a copper-base alloy have been accepted by most of the hydraulic industry because of their low cost as compared to stainless steel. Aluminum exchangers are possible but are not easily fabricated, nor are they easily repaired in the field.

Design Considerations: The shell-and-tube heat exchanger or other forced-convection cooling equipment should be installed on the low-pressure side of a circuit in order to keep the cost low. The heat-transfer equipment should be protected from rupture by a bypass and relief valve. Because high-pressure exchangers are expensive it is often advantageous to have a separate circulating pump, circulating oil from the sump or tank through the cooler and back to the tank in order to keep the cost of the exchanger down.

In piping heat-transfer equipment, in order to do the best cooling job, counter-flow should be maintained so as to take advantage of the maximum mean temperature difference available. Oil viscosities should be kept low, and highest velocities consistent with allowable pressure drop should be maintained in the cooling equipment for maximum heat transfer.

Usually the most economical shell-and-tube heat exchangers will be those with closest tube pitch and smallest diameter tube, consistent with fouling characteristics, allowable pressure drop and mechanical design. Baffles should fit the shell and tubes snugly and the tube bundle should fit the shell ID closely with minimum clearance between tube and shell. Fixed-tube-bundle design will be lower in first cost.

From a paper entitled "Heat: Forced Convection Removal from Industrial Hydraulic Circuits" presented at the 10th National Conference on Industrial Hydraulics in Chicago, October, 1954.

Design considerations for

Weldable Titanium

By Arnold S. Rose
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WELDABLE grades of titanium are primarily commercially pure alloys which are classified under such grades as AMS 4900, AMS 4901, AMS 4921 and under commercial designations such as Ti-75A, RC-A55, RC-A70, RS-70, MST Grade III, etc. Commercially pure titanium at room temperature and at temperatures up to approximately 1600 F exists in a hexagonal close packed crystal structure, the alpha phase. This structure allows the material to be bent and formed with some effort at room temperature, although heating to approximately 1000 to 1200 F increases its ductility measurably. In combination with the drop in yield strength at elevated temperatures, this characteristic greatly improves formability.

A recently developed variation from commercially pure titanium is an all-alpha-phase weldable alloy containing 4 per cent aluminum and 2 per cent tin, Rem-Cru's A-110AT grade. This alloy, whose properties at elevated temperature are superior to the commercially pure grades, is readily welded and fabricated. A comparison is shown in *Fig.* 1 of the yield strengths of this alloy and the commercially pure titanium.

Forming and Forging: Sheet metal RC-A70 varying in thickness from 0.025 to 0.140-inch has been rolled into cylinders and conical sections with diameters ranging from 10 to 48 inches. These have been rolled at room temperature with no difficulty. Sheet titanium 0.180-inch thick and bar stock ranging in section between ½ by ½-inch to 3 by 4 inches have required hot rolling.

In view of low volume requirements and correspondingly high value, many parts have been hot-formed. Parts as thin as 0.025-inch have been successfully hot-formed. Several parts formed in this manner are shown in *Fig.* 2. The forging of the plate illustrated in *Fig.* 3 began with a section of RC-A70 bar stock 2 by 4 by 14 inches which was upset into a billet 4 by 4 by 10 inches.

Spinning: Titanium is successfully spun at elevated temperatures. A typical spinning is shown in *Fig.* 4. It was hand spun from a rolled conical section of 0.140-inch thick titanium on which the mating edges had been welded by means of an inert gas-shielded tungsten arc.

A mechanized method which differs markedly from conventional hand spinning is involved in the shear forming of sheet metals to produce conics. This process, which has been used extensively for the manufacture of metal cones for television tubes, actually produces a reduced section in the portion being spun. The essential differences between the two processes are illustrated graphically in *Fig.* 5. With manual spinning,

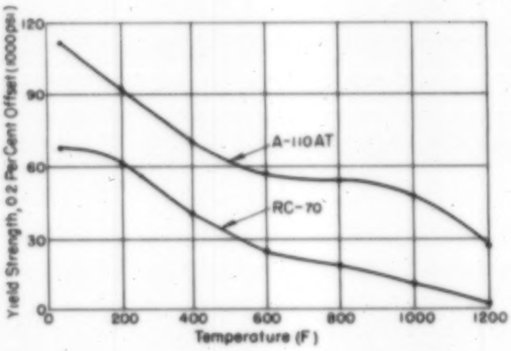

Fig. 1 — Curves of yield strength versus temperature for commercially pure titanium (RC-70) and an aluminum-tin titanium alloy (A-110AT)

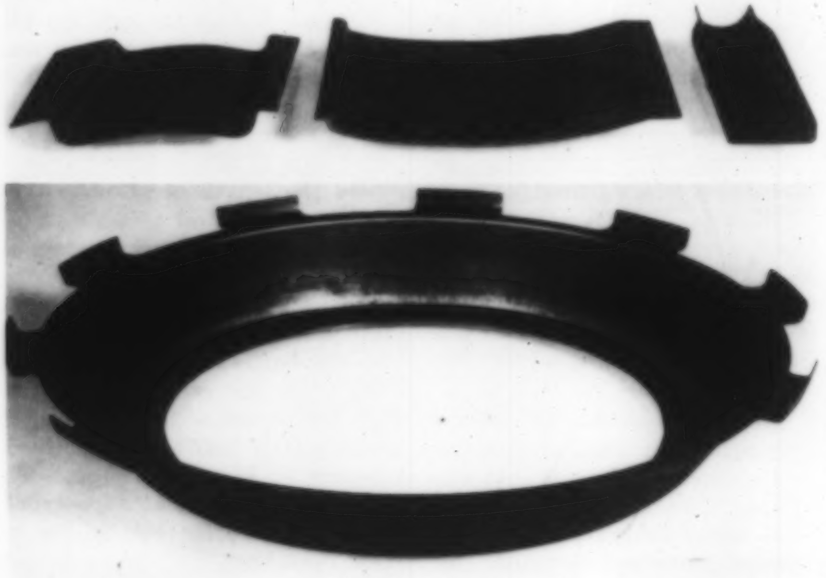

Fig. 2—Titanium parts hot-formed on a drop-hammer

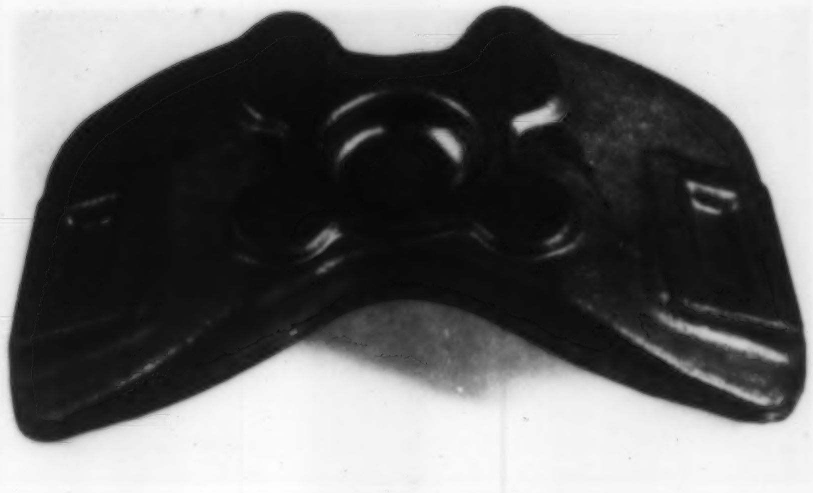

Fig. 3—Forged titanium plate

reduction in the finished part diameter results, as shown by cone B_1, spun from an original blank size A_1. With mechanical shear forming, starting with the same size blank A_2, the cone wall is reduced (as a function of the sine of the spinning angle) and the finished cone diameter is precisely that of the initial blank. As an example, a 16-inch diameter blank, 0.100-inch in thickness may be mechanically spun into a 16-inch diameter cone B_2 whose wall thickness is 0.045-inch.

A photograph of a mechanically finished 16-inch diameter titanium cone is shown in *Fig.* 6.

Resistance Welding: The spot, overlap-spot, and seam welding of RC-A70 titanium has been performed with no difficulty and with excellent results. Thicknesses of 0.062-inch have been spot welded successfully. Seam welding of 0.045-inch thicknesses has also proven feasible.

One outstanding feature of resistance welding on titanium is the tendency to excessive penetration of the weld nugget into the parent materials. This effect may be limited by proper weld set-ups to acceptable values.

When seam or spot welding dissimilar thicknesses, it has been found that penetration into the thinner sheet titanium increases as the disparity in thicknesses increases. When welding a combination where the heavier metal was four times the thickness of the thinner sheet, penetration over the 80 per cent considered permissible was obtained. A practical working limit, therefore, for dissimilar metal thicknesses may be taken as a ratio of 3 to 1.

Arc Welding: Titanium over 0.100-inch thick requires high welding currents (approximately 200 amperes) and, therefore, special equipment, such as a helium-filled welding chamber, to prevent severe oxidation and embrittlement. Examples of titanium welded in a helium-filled chamber include heavy 2 by 2 inch titanium bar

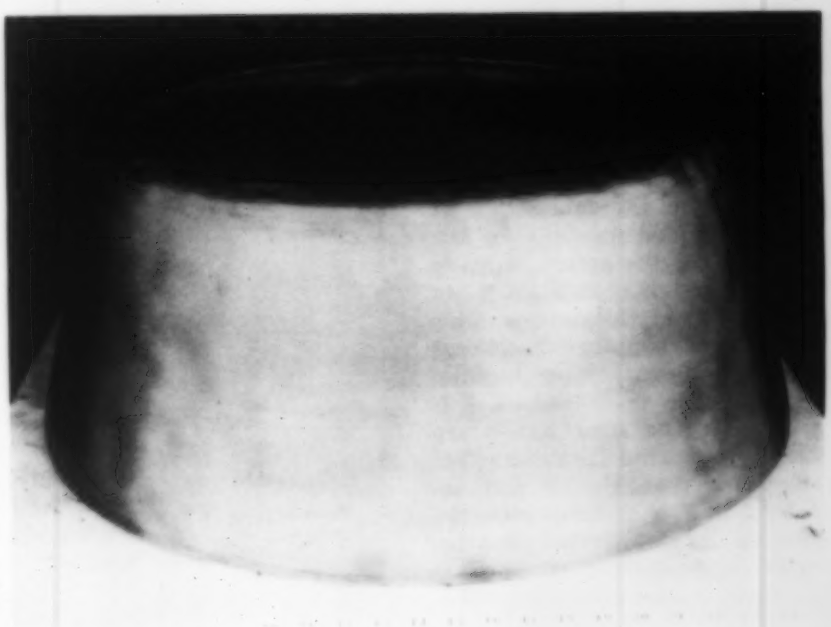

Fig. 4—Manually spun cone of 0.140-inch thick titanium

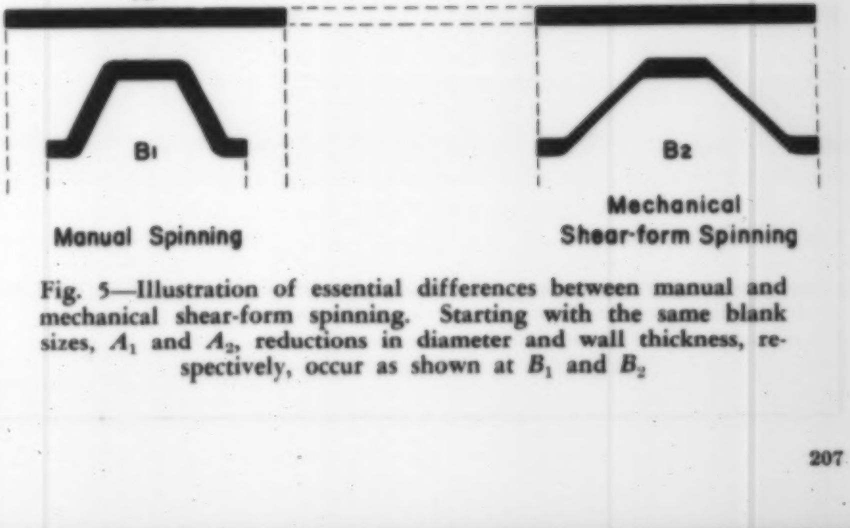

Fig. 5—Illustration of essential differences between manual and mechanical shear-form spinning. Starting with the same blank sizes, A_1 and A_2, reductions in diameter and wall thickness, respectively, occur as shown at B_1 and B_2

stock which has been rolled into ring shape.

Quality of welding performed in the chamber is shown by a series of tests run on RC-A70 titanium comparing the ductility of material as-received against welded samples. No significant change in the as-welded ductility from that of parent material was noted. This was checked by selecting only the welded portion of a 0.140-inch thick butt joint for tensile testing. The value of 22 per cent elongation (in 2 inches) for the all-weld-cast-metal sample is approximately equivalent to that of the parent wrought material. Such values are also obtainable on welds made outside the chamber, but complete shielding of the weld is essential for such ductility to be maintained consistently.

Another example of the type of work which can be done only in a completely protective atmosphere such as provided by the helium chamber is in the fabrication of airfoil contour struts, *Fig.* 7. The outer skin of the struts is made by butt welding 0.063-inch to 0.140-inch sheet thicknesses. This is done by clamping the pieces against a grooved copper back-up and welding in the chamber. Following this, the strut halves are formed to airfoil contour. The halves are then slotted and assembled into a fixture with the stiffeners in place. The joint between stiffeners and skin is "through" welded through the slotted skin, and with copious filler wire addition, the internal fillet is cast against the copper back-up blocks. Following this, the leading edge of the strut is through-welded in a similar manner. Trailing edges are resistance seam welded.

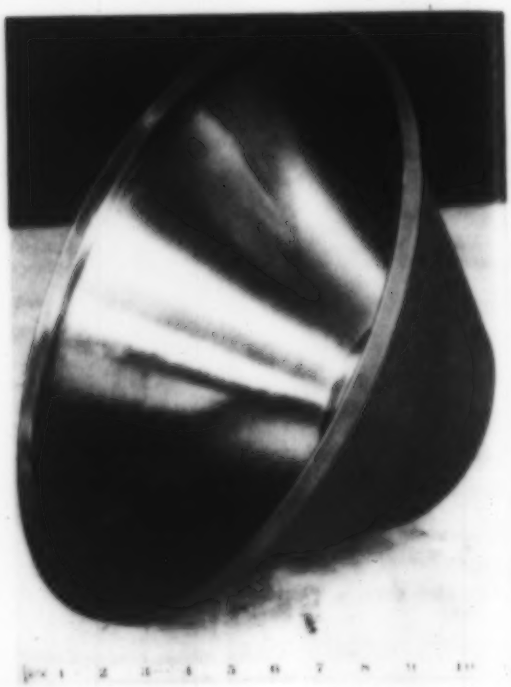

Fig. 6—Mechanically spun titanium cone, 16 inches in diameter

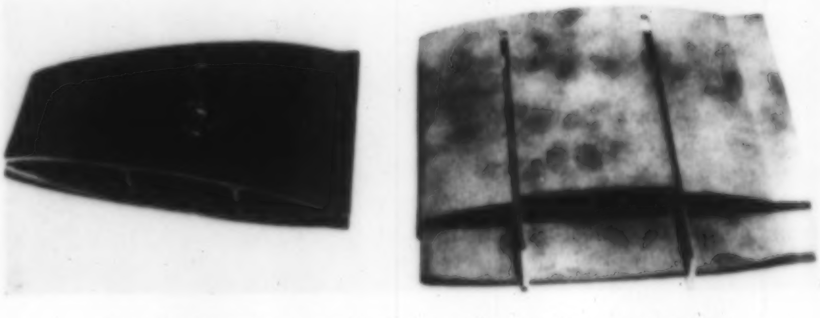

Fig. 7—Titanium airfoil strut after welding and trimming, left, and before welding, right

From a paper entitled "Fabrication of Titanium Components" presented before the American Rocket Society at the 1954 *ASME Semi-Annual Meeting in Pittsburgh, Pa.*

Shrink and expansion fitting applied in

Subzero Assembling Processes

By H. T. Gregg, Jr.

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SHRINK-FIT assembling involves heating the outside fitting and allowing it to shrink around the center plug, stud or bushing—a procedure often impractical or even impossible because of damage caused by the necessary high temperature. This is true of certain steels and most aluminum alloys. However, if the internal part is subcooled, heating of the external part is either eliminated or reduced to a temperature that will not damage the part.

This method of expansion-fit assembly can frequently be used to replace hydraulic press equipment where a press-fit assembly is being made. Simply by cooling the internal part, an assembly that

Table 1—Contraction of a 2-Inch Diameter Cylinder Cooled from 70 F

Rockwell Hardness	Material	Contraction at −110 F (in.)	−160 F (in.)	−320 F (in.)
C63	High-speed steel 18-4-1	0.0022	0.0028	0.0039
C64	High-speed steel 6-5-4-2	0.0021	0.0026	0.0040
C65	High-speed steel 18-4-2 + 9 Co	0.0020	0.0026	0.0035
C64	High-speed steel 5-4-4-4	0.0025	0.0032	0.0045
C67	High-speed steel 4-5-4-1 + 12 Co	0.0020	0.0023	0.0031
C66	Tool steel: 1.10 C	0.0024	0.0028	0.0039
C63	Tool steel: 0.90 C, 1.20 Mn, 0.50 Cr, 0.50 W	0.0023	0.0027	0.0040
C66	Tool steel: 0.50 C, 0.90 Cr, 1.25 W	0.0024	0.0029	0.0036
C64	Tool steel: 2.25 C, 12.00 Cr, 1.00 Mo	0.0025	0.0027	0.0040
C58	Chrome-vanadium steel (SAE 6150)	0.0026	0.0029	0.0044
B86	Machine steel (SAE 1020)	0.0023	0.0028	0.0044
B85	Cast iron	0.0022	0.0025	0.0037
B82	Stainless steel (18-8)	0.0033	0.0041	0.0057
B60	Brass (66-34)	0.0041	0.0046	0.0072
F82	Copper	0.0036	0.0038	0.0062
F78	Bronze (SAE 660)	0.0038	0.0043	0.0065
H64	Aluminum (2S)	0.0043	0.0056	0.0062
E98	Aluminum (24S-T; 2024-T)	0.0031	0.0055	0.0080
H79	Magnesium (M)	0.0051	0.0063	0.0094
B78	Invar '36'	0.0003	0.0005	0.0011
C69	Cast alloy: 20 Co, 8 W, 7 Mo, 5 Cr, 2 V, 0.7 C, 0.7 B, bal Fe	0.0018	0.0022	0.0029
C58	Cast alloy: 44 Co, 17 W, 33 Cr, 2.25 C, 2 Fe	0.0020	0.0025	0.0035
A91	Carboloy (Grade 44A)	0.0003	0.0006	0.0015

Data obtained by General Electric's Construction Materials Laboratory.

previously required tons of pressure can be made by hand. Expansion fitting also has distinct advantages over press fitting. It can increase production and lower manufacturing costs as well as prevent unnecessary strains from being set up, and it avoids scoring of the mating surfaces.

A few of the many sub-zero assembling applications include:

1. Assembling cast-alloy valve seat rings in automobile cylinder blocks.
2. Placing an alloy-steel ring around coining or cold-forging dies to prevent splitting.
3. Assembling case-hardened ring gears without tempering the case.
4. Inserting steel ball-bearing races in a cast-iron housing.
5. Assembling bearings and bushings of all sizes and shapes.

Low temperatures are also useful in removing certain assembled parts. With large bushings, for example, it's possible to insert a tight-fitting cup-type container filled with a subzero-cooled convection fluid. Under favorable circumstances, including low enough temperatures, bushings and similar parts can be removed in this manner.

An indication of the range of allowances for subzero assemblies is given in *Table* 1. These data were obtained by using test specimens 2 inches in diameter and 1 inch long with a ⅜-inch center hole. Each specimen was cooled from 70 to −110, −160 and −320 F. Actual contraction of the 2-inch diameter was measured while the test pieces were at the respective subzero temperatures.

From "Sub-Zero Treatment of Metals" in General Electric Review, *July*, 1954.

Design factors for

New Cast Stainless Alloys

By H. J. Cooper and N. S. Mott
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TWO recently developed precipitation hardenable stainless steel alloys combine excellent corrosion resistance with high strength, hardness and galling resistance. These properties are produced by simple low-temperature heat treatment. One of these is Armco 17-4 PH, an alloy which uses copper as a precipitation hardening element. The other is Cooper Alloy V2B which uses beryllium as the hardening agent. Armco 17-4 PH has excellent resistance to salt-water corrosion and pitting as well as to a large group of less corrosive chemicals, such resistance approaching that of type 304 stainless. Cooper Alloy V2B is designed to handle the more severe corrosive chemical media, its resistance being equal to or better than type 316 in most instances. Both alloys can be cast into a wide variety of shapes.

Other compositions coming into important use are Type FA-20 and the ELC stainless grades. Type FA-20 has advanced from relative obscurity to become one of the important stainless compositions available for highly corrosive applications. Engineers and designers will find it useful in the construction of equipment where higher pressures and more exacting corrosives have to be handled.

Loss of availability of the element columbium — employed to stabilize stainless steel of chromium-nickel type and make it resistant to intergranular corrosion after constructional welding—has presented a tremendous problem. At first it was thought that titanium could be used as a substitute element, but difficulties in casting operations have limited its use to the wrought field. Even there it is not too popular. Now castings containing very low carbon (less than 0.03 per cent) in stainless steel types 304 ELC and 316 ELC are being produced by special oxygen blowing melting techniques; in the resulting alloys harmful carbide formation occurs so slowly and to such a minor extent that normal welding practice has no noticeable effect on corrosion resistance.

Armco Alloy Type 17-4 PH is a precipitation hardenable alloy designed for use where a reasonably low-cost material having high hardness, strength, galling and corrosion resistance is desired. Its corrosion resistance exceeds that of the 12 per cent chromium alloy usually used to secure similar mechanical properties of high strength and hardness, and approaches that of 18-8. It is especially resistant to sea-water corrosion and pitting, and is recommended for ship propellers, pump impellers and other marine applications. In food and chemical industries its use in any mildly corrosive application satisfactorily handled by 18 per cent chromium alloy is recommended where strength, hardness and galling is a problem.

It is readily machinable in the solution annealed state and, when hardened, has in addition to the excellent mechanical property of high strength, an appreciable amount of ductility and toughness. Mechanical property values in castings are listed in *Table* 1.

Heat treatment consists of solution annealing the alloy by water or oil quenching, or by air cooling from 1800-1850 F after one hour at that temperature, followed by precipitation hardening for one hour at 850-900 F with air cooling.

The hardening treatment produces at most only a light heat tinting discoloration which is easily removed by a short light pickle in warm dilute nitric acid. Of special importance is the fact that stress relieving is unnecessary since no cracking of any sort is ever produced, as sometimes happens with the hardenable chromium alloys.

Table 1—Mechanical Properties of Alloy 17-4 PH

Property	Solution Annealed	Hardened
Tensile strength (psi)	152,000	179,000
Yield point (psi)	83,000	150,000
Elongation (per cent)	5	4
Reduction of area (per cent)	8	7
Hardness (Rockwell C)	34	41
Impact resistance (Izod)	27	17

Table 2—Mechanical Properties of Alloy V2B

Property	Quench Annealed and Hardened
Tensile strength (psi)	151,600
Yield strength (psi)	122,400
Elongation (per cent)	3
Reduction of area (per cent)	2
Hardness* (BHN)	363

Hardness after 50 hours at elevated temperatures:

Temperature F	Hardness (BHN)
70	340
800	340
900	340
1000	340
1100	302
1200	332
1400	351

*Hardness (BHN) as cast is 302 and after quench annealing is 269.

Welding is accomplished by any of the usual methods using 17-4PH welding rod, and no intergranular corrosion embrittlement results from the welding heat effect. If fully hardened material is welded, a hardening treatment at 900 F will bring the properties of the weld joint close to those of the parent metal.

Cooper Alloy Type V2B is a hardenable 18-8 type containing copper, molybdenum, silicon and a small amount of beryllium developed for high strength, nongalling, nonseizing characteristics in corrosive service. It has high hardness, superior corrosion resistance, and maintains hardness at temperatures up to 1400 F. It is readily machinable in the quench-annealed state and may be hardened by a low-temperature heat treatment which produces no distortion and only a light heat tinting discoloration, which can be readily removed if necessary. In the annealed condition the material is easily welded using special V2B welding rod.

Its high hardness and strength, excellent resistance to corrosives and nongalling characteristic suggest many applications, such as valve disks, lug cocks, shaft sleeves, impellers, pump casings, wearing rings, poppets, conveyor links, rollers and gear blanks.

V2B, unlike other precipitation hardenable alloys, does not overage and loose hardness at elevated temperatures up to 1400 F and therefore opens a new application range where hardness, galling and corrosion resistance are necessary at more elevated temperatures. Mechanical property values in castings are shown in *Table* 2.

Heat treatment of V2B consists of water quenching from 2000 F to put carbides and hardening constituents into solution. Following this the alloy is machined to shape and then hardened by holding at 925 F for eight hours followed by furnace cooling. The slight heat tinting discoloration may be removed if necessary by a short pickle in dilute nitric-hydrofluoric acid mixture.

Alloy Type FA-20 was originally used mainly for resistance to sulfuric acid. Through increase in demand by the chemical industry for a superior corrosion-resisting stainless alloy over type 316, it has come into greater prominence. It offers superior resistance in hot strong solutions of calcium or magnesium chlorides and aluminum sul-

Table 3—Mechanical Properties of Alloy FA-20

Property	Solution Annealed
Tensile strength (psi)	69,000
Yield point (psi)	31,500
Elongation (per cent)	48
Reduction of area (per cent)	55
Hardness (BHN)	140
Impact resistance (Charpy)	70

Table 4—Mechanical Properties of Alloys 304 & 316 ELC

Property	—Quench Annealed—	
	304 ELC	316 ELC
Tensile strength (psi)	75,000	78,000
Yield point (psi)	35,000	40,000
Elongation (per cent)	55	50
Reduction of area (per cent)	65	60
Hardness (BHN)	135	155

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fate; in dilute solutions of tin, zinc, iron or mercury chlorides at room and slightly elevated temperatures; and in cold dilute solutions of sodium or calcium hypochlorite. It is also superior in sulfur dioxide solutions or sprays and in sodium or potassium hydroxide solutions of over 30 per cent when hot or boiling.

In sulfuric acid its use is mandatory when the concentration is over 40 per cent at room temperature, 10 per cent at 175 F, or 0.75 per cent at boiling; and it is satisfactory in all concentrations of this acid up to 150 F or sometimes higher, and up to 40 per cent at boiling. In hydrochloric acid it is resistant in the cold up to 20 per cent, while 316 will stand up against only traces of this material. It is recommended at all concentrations and temperatures in phosphoric acid where type 316 often fails very suddenly.

The alloy contains a much higher nickel content and in addition contains copper which, however, is held in alloy solution by the higher nickel. These together with the chromium and molybdenum in balanced proportions make for the highly corrosion resistant all-around alloy of moderate cost and excellent mechanical properties. Mechanical property values in castings are given in *Table* 3.

The high resistance of FA-20 in various corrosive media, plus its excellent mechanical properties and moderate cost is making it a very popular alloy, and it is being produced in valves, pump units, pipe fittings and a wide variety of cast shapes used in the chemical, textile, paper, plastic and petroleum industries.

Alloy Types 304 & 316 ELC

obviate carbide precipitation at grain boundaries such as would be caused by weld heating in the absence of stabilizing columbium. Under severe corrosive conditions intergranular corrosion failure would otherwise occur. As the extent of carbide precipitation is a function of time as well as percentage carbon content and temperature, the short time intervals in welding operations are not sufficient to cause structural damage in these low carbon grades. Mechanical property values in castings are listed in *Table* 4.

Corrosion resistance of the ELC grades is practically the same as for the usual low-carbon types with the exception of the less tendency towards the intergranular type. Welding, of course, would be done with a corresponding analysis low-carbon rod.

From "The Newer Cast Stainless Alloys" in Cooper Alloy Corp. Newscast, *October*, 1954.

Designing Man-Machine Systems

By Robert P. MacNeil

Head, Human Factors Section
Electric Boat Div.
General Dynamics Corp.
Groton, Conn.

HUMAN engineering is the art of getting the most performance out of a man-machine system. Since the operator is pretty well fixed as a design element, improvement of man-machine performance must rely on designing the machine to suit the operator.

Every man-machine system is comprised of four basic elements: control, machine, instrumentation and man. The four are linked to each other in the order named and form a closed loop with "man" linked to "control."

Control: Taking the first of the four elements, control, the engineer wants to know what is controlled. Is it temperature, speed, force, direction, flow or what? He wants to know that to determine what direction and kind of motion the control should have to be compatible with the thing controlled. He also wants to know if the operator is sitting or standing and how much effort the control requires, in order to suggest the proper placement and size. With a good control, an operator can get feedback information telling him whether the controlled item is going up or down, fast or slow, how fast it is changing, etc.

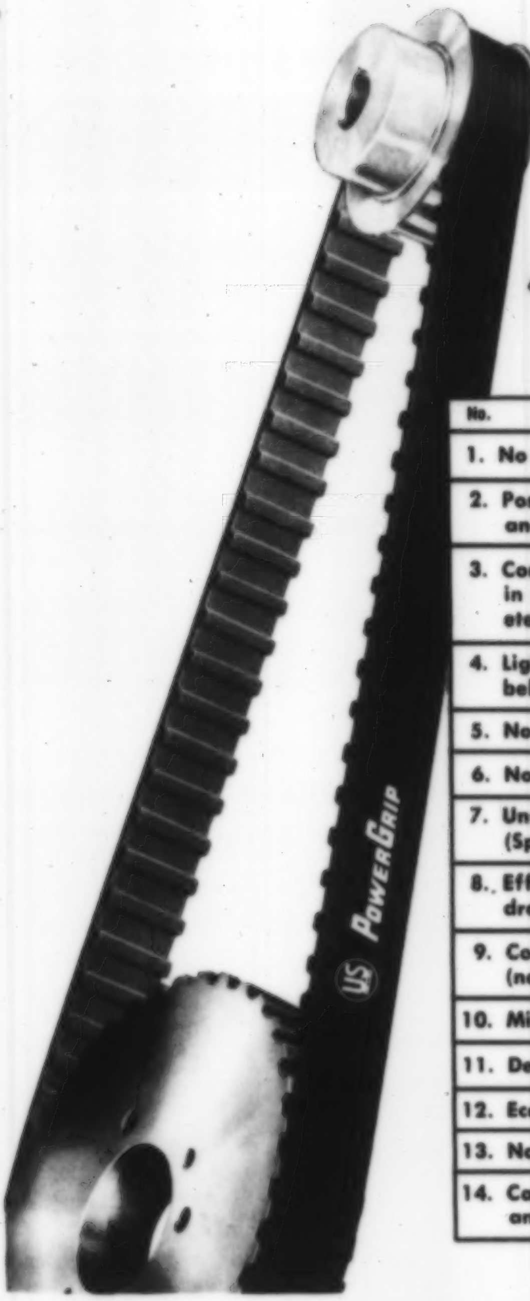
Machine: The next item, the machine in the closed-loop diagram, pretty well takes care of itself since there is little human factor design here. It was interesting to note in the papers recently, however, that a newly installed machine in a midwest plant was so big and terrifying that the assigned operators refused to run it. At any rate, the machine itself is a passive element and can be bypassed for this discussion.

Instrumentation: This has been the human engineer's most fertile field, primarily because of the great need for new thought in aircraft cockpits where instrumentation is very critical.

Good instrumentation should tell the operator all he needs to know, but no more than that. Instrumentation is pure communication. The instruments should be simple in appearance and should tell the right story clearly and unmistakably. A tachometer is fine if you're interested in crankshaft speed but what would happen if you told the cop you were only doing 2300 rpm?

Operator: The last part of the closed loop is the man or the operator. At his job he can work better if he has the proper controls and gets the proper information either by order or by feedback from the controls and the instrumentation he is using. The positioning, shape, size and operation of controls must be natural and convenient. In the operator's visual field all tonal and color contrasts should be kept low except on gage dial markings and labels where maximum contrast is best.

From a paper entitled "The Anatomic Submarine" presented at the Industrial Designers' Institute symposium in Norwalk, Conn., October, 1954.



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5. No noise or vibration	✓				
6. No initial tension	✓				
7. Unusual speed range (Speeds up to 12,000 FPM)	✓				
8. Efficient (Elim. heat, lube drag, high bearing loads)	✓				
9. Constant angular velocity (no speed fluctuation)	✓				
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NEW PARTS AND MATERIALS

For additional information on these new developments, see Page 215

Indicator Lights

Miniature neon indicator lights for appliances and other applications can be supplied with wire leads or blade type quick disconnects. Built-in resistors eliminate the need for transformers or series hook-ups. A wide range of lens colors and configurations is available, and special shapes in the form of company trademarks or other devices can be produced. Made by **Ucinite Co.,** Newtonville 60, Mass.

For more data circle MD-66, Page 215

Speed Reducer

Redesigned horizontal DOX double reduction speed reducer, with zinc alloy housing, is available in ratios of 4:1 to 1600:1. Torque capacities are 25 to 150 lb-in., utilizing 1/6-hp. Standard reducers are furnished with roller bearings; bronze sleeve bearings are also available. Applications include food market conveyors, domestic stokers, farm spreaders, pump drives and light industrial applications. Made by **Ohio Gear Co.,** 1333 E. 179th St., Cleveland 10, O.

For more data circle MD-67, Page 215

Temperature Controls

Small disk type C-4344 series controls are available in preset temperature settings. Differentials between opening and closing temperature settings may be 15 deg and higher. The 125 to 250-v units operate at temperatures ranging from 60 to 250 F; those rated to 30 v ac or dc operate in temperature range of 250 to 400 F. The snap-acting disk is located opposite the terminal end of the control, at the bottom of the metal enclosure, where temperature of air, liquids or the mounting surface can be followed clearly. Made by **Metals & Controls Corp.,** Spencer Thermostat Div., Forest St., Attleboro, Mass.

For more data circle MD-68, Page 215

Self-Aligning Bearings

Flange mounted, self-aligning F100 series bearings are designed for machine frame applications such as farm machinery, conveyor, power transmission, blower and fan installations. Bearing assembly is mounted in a frame opening and attached by three bolts which are tightened after the shaft has been inserted and aligned. Tightening the three holding bolts clamps the bearing in a fixed position; two setscrews lock it in place. Bearings have labyrinth composition seals which retain lubricant and exclude foreign material. Available in shaft sizes ranging from ½ to 1¼ in., they are recommended for medium loads and maximum speed of 5000 rpm. Made by **Nice Ball Bearing Co.,** 2925 Hunting Park Ave., Philadelphia 40, Pa.

NICE
PHILA.
PENNA

For more data circle MD-69, Page 215

Blower Drive Motor

Type CY MicroMotor, used for direct-drive of heating, ventilating and refrigerating apparatus blowers, has no starting switches or relays. Starting and running current

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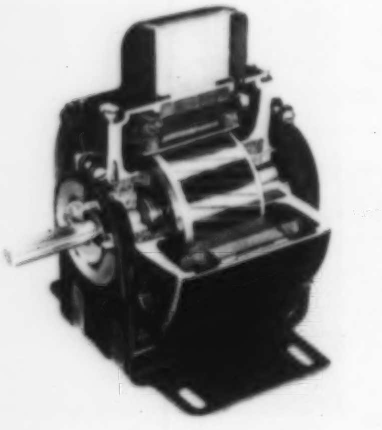
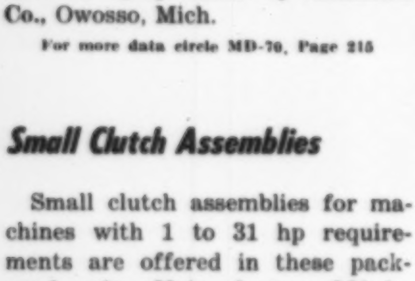
is low, power factor is high, and torque build-up is gradual. Motor is also suitable for multispeed operation and mounting in any position. Uni-Cast motor stator and die-cast frame prevent shifting and vibration of laminations. Completed core, end bells, bearings and shafting are machined for quiet operation and long life. This split-capacitor motor is available in sizes from 1/10 to ⅓-hp. Made by **Redmond Co.,** Owosso, Mich.



For more data circle MD-70, Page 215

Small Clutch Assemblies

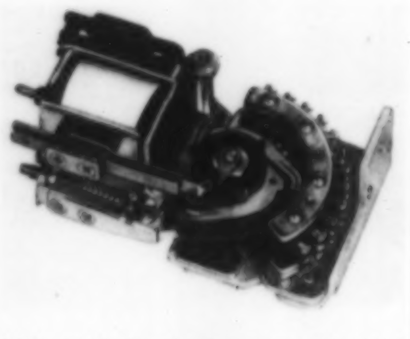
Small clutch assemblies for machines with 1 to 31 hp requirements are offered in these packaged units. Units feature 360-degree engagement, uniform friction pressure, instant response to electro-pneumatic controls, automatic compensation for wear and complete disengagement. They adapt to cyclic or continuous operations and can be controlled locally or remotely. Illustration shows spider bearing mounted unit, which incorporates an extended drum hub mounted on antifriction bearings. Spider gap mounted unit for installation direct to mating component and spider close mounted unit for flexible coupling service are also offered. All provide overload protection. Made by **Fawick Corp.,** Fawick Airflex Div., 9919 Clinton Rd., Cleveland 11, O.



For more data circle MD-71, Page 215

Stepping Switch

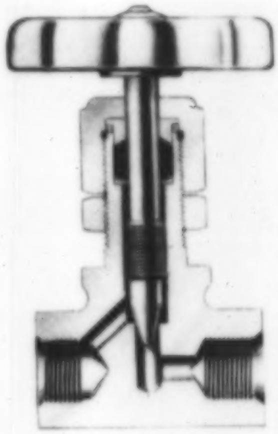
Type 11 spring-driven stepping switch which functions as either an 11-point or a 10-point switch, is capable of millions of operations without adjustment. It can be employed for selecting any desired point in a series, selecting the first unoccupied point in a series, sequence controlling, counting and totalizing, generating timed impulses and monitoring. Switch can be provided with from one to eight bank levels of 10 or 11 points each. Each bank level is traversed by a pair of wiper springs. Rotor is driven by a stainless steel ratchet wheel which has 33 teeth. Wipers can be arranged so that several bank levels can be used independently or in tandem. Switch can be hermetically sealed. Made by **C. P. Clare & Co.,** 3101 Pratt Blvd., Chicago 45, Ill.



For more data circle MD-72, Page 215

Needle Valve

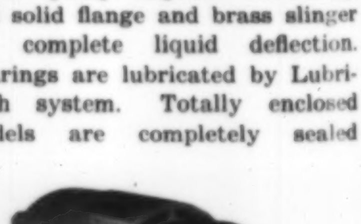
Designed for use at pressures to 10,000 psi and temperatures to 200 F, and for water, gas, oil and vacuum service, this T-shaped needle valve is made with a one-piece, stainless steel forged body. The semi-needle stem is hardened stainless steel. It has fine, 40-pitch micrometer threading for metering and ease of turning. A locknut to facilitate panel mounting is optional. Packing can be graphited asbestos or Teflon. Valve is available with female pipe thread connections in ⅛, ¼, ⅜ and ½-in. sizes. Made by **Republic Mfg. Co.,** 15655 Brookpark Rd., Cleveland 11, O.



For more data circle MD-73, Page 215

Pump Motors

Line of totally enclosed and explosionproof close-coupled pump motors, designed for use with centrifugal pumps, is available in 1½ to 25-hp range. Motors have face type registered mounting bracket for accurate shaft alignment and simplified pump mounting, precision ground shaft for accurate pump impeller mounting, and solid flange and brass slinger for complete liquid deflection. Bearings are lubricated by Lubriflush system. Totally enclosed models are completely sealed against destructive dusts, acid fumes, excessive moisture and other harmful substances. Larger models are double-enclosed and fan-ventilated for rapid heat dis-



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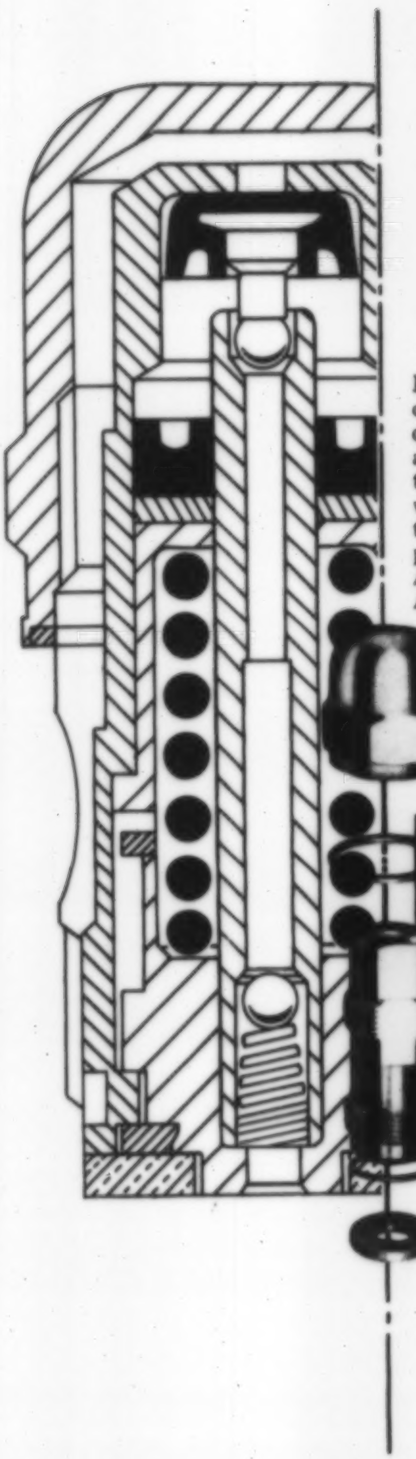

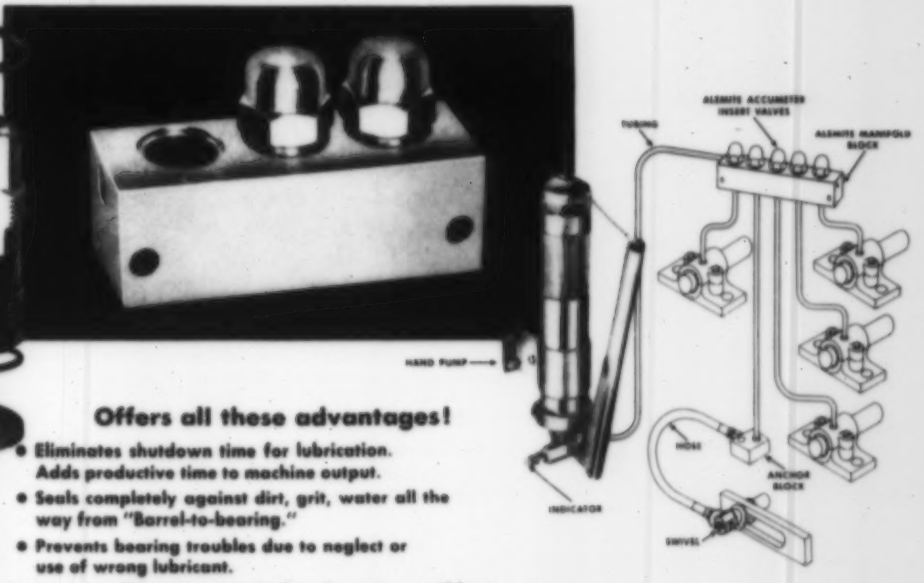

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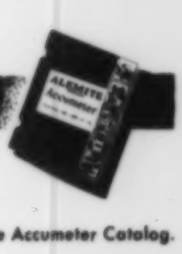

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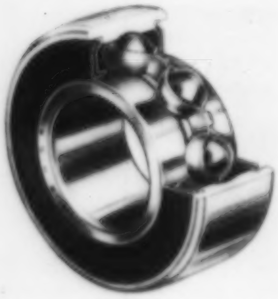
For more data circle MD-74, Page 215

Wide Sealed Ball Bearings

Made in standard bores and outside diameters, W-KLL series Mechani-Seal ball bearings are as wide as those of corresponding size double-row bearings. They are designed especially for applications requiring frictionless sealing and large grease capacity. Seven sizes cover bore diameters from 0.9843 to 2.1654 in. with corresponding rated radial load capacities of 514 to 2610 lb at 3600 rpm. Bearings are prelubricated with factory-filtered grease. Made by **Fafnir Bearing Co.,** New Britain, Conn.



For more data circle MD-75, Page 215

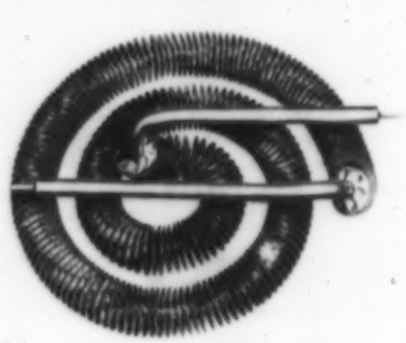
Flexible Connectors

Flexpipe connectors, for air, gas, oil, steam or water, dampen vibration, compensate for expansion and contraction in risers and supply lines, connect outlets which are not in line and compensate for other piping travel. They are made of seamless phosphor bronze tubing which has corrugated walls to provide flexibility. Brass NPT male fittings are attached to both ends of the connectors, and the tubing is covered with wire braid. Assemblies are available in sizes of ¼-in. ID and 8 or 16 in. long through 1½ in. ID and 14 or 28 in. long. A 2-in. ID size is made in 18-in. length only. For intermittent elongation and contraction, maximum offset each side of centerline can be ½-in. for shorter connector lengths and 1¼ in. for longer connectors. Working pressures range from 1200 to 200 psi at room temperature and 850 to 125 at maximum operating temperature of 350 F for smallest to largest sizes, respectively. Made by **American Brass Co.,** American Metal Hose Branch, Waterbury 20, Conn.

For more data circle MD-76, Page 215

Finned Electric Heaters

Slim-fin electric heaters, made by brazing spirally-wound steel fins to standard rod type heating element, are formed to shape before fins are attached. Fins can be spaced from four to eleven to the inch. The 0.312-in. tubing has 15/16-in. wide fins and is adaptable to all types of convection heating. Capacities range from 500 to 2000 w. Made by **Ferrod Mfg. Co.,** 603 N. River St., Batavia, Ill.



For more data circle MD-77, Page 215

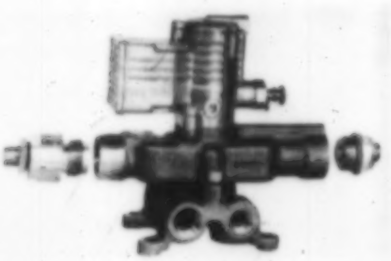
Cycling Power Feed

Cam-controlled automatic cycling power feed for precision metal-working operations consists of a slide assembly, feed mechanism, cam drive motor and housing. Any desired tooling set-up can be mounted on the slide. The unit can be used for drilling, tapping, boring, reaming, sawing, milling, broaching and other precision work on parts of relatively small size. Variation in feed cycles is effected by changing cams. Unit measures 17 in. long, 6 in. wide and 8⅛ in. high to the top of the motor housing. It can be mounted horizontally, vertically or at any angle. Working surface is 4 x 6 in.; maximum stroke is 2 in. Gearmotor which rotates the cam delivers torque of 52 lb-in. Cycle times of 4, 6, 8, 10, 12 and 16 seconds per revolution are standard. Made by **Russell T. Gilman Inc.,** 1243 Milton Ave., Janesville, Wis.

For more data circle MD-78, Page 215

Speed Control

Speed control can be added to Speed King solenoid pilot-operated valves without using separate valves between the control valve and the cylinder. This is accomplished by addition of adjusting screws in the end caps which will restrict the stroke of the main stem of the valve and thus restrict the flow of cylinder exhaust air through the valve. Kits are available to convert valves already in service to controlled speed. Speed King valves with built-in speed control are available in four-way foot-mounted and sub-base mounted, single and double solenoid types



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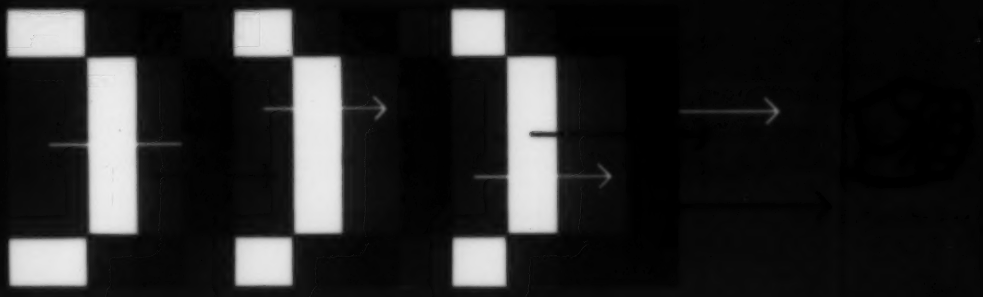

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No other cylinder offers you so many vital features: compact, streamlined design; lightweight aluminum alloy and steel construction exceeds all strength requirements; interchangeable mountings — foot, flange, pivot, clevis and trunnion. Every cylinder can *operate with air, water or oil without interchanging or adding parts:* Adjustable cushioning (optional) can be added to any cylinder at any time.

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3. Self-compensating synthetic multiple "V" rod packing.
4. Rod packing and bearing externally removable.
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6. Rotatable end caps allow 360° piping location.
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8. Bronze piston bearing assures maximum support.
9. Ground and polished stainless steel piston rod.
10. Synthetic "U" cups automatically adjust for wear.

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in $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1-in. sizes. Made by **Valvair Corp.,** 454 Morgan Ave., Akron 11, O.

For more data circle MD-79, Page 215

Miniature Flexible Coupling

Applicable in timing machinery, electronically controlled automatic machines and servo motors, this miniature coupling weighs $\frac{1}{2}$-oz. Of aluminum-beryllium copper construction, it is nonmagnetic. Coupling has no sliding parts. Backlash is minimum, and crosspull and end thrust on connected shafts are practically eliminated by flexibility of the coupling. Furnished in all bore sizes up to $\frac{1}{4}$-in., it operates at speeds to 50,000 rpm. Torque rating is 50 lb-in. Made by **Thomas Flexible Coupling Co.,** Warren, Pa.

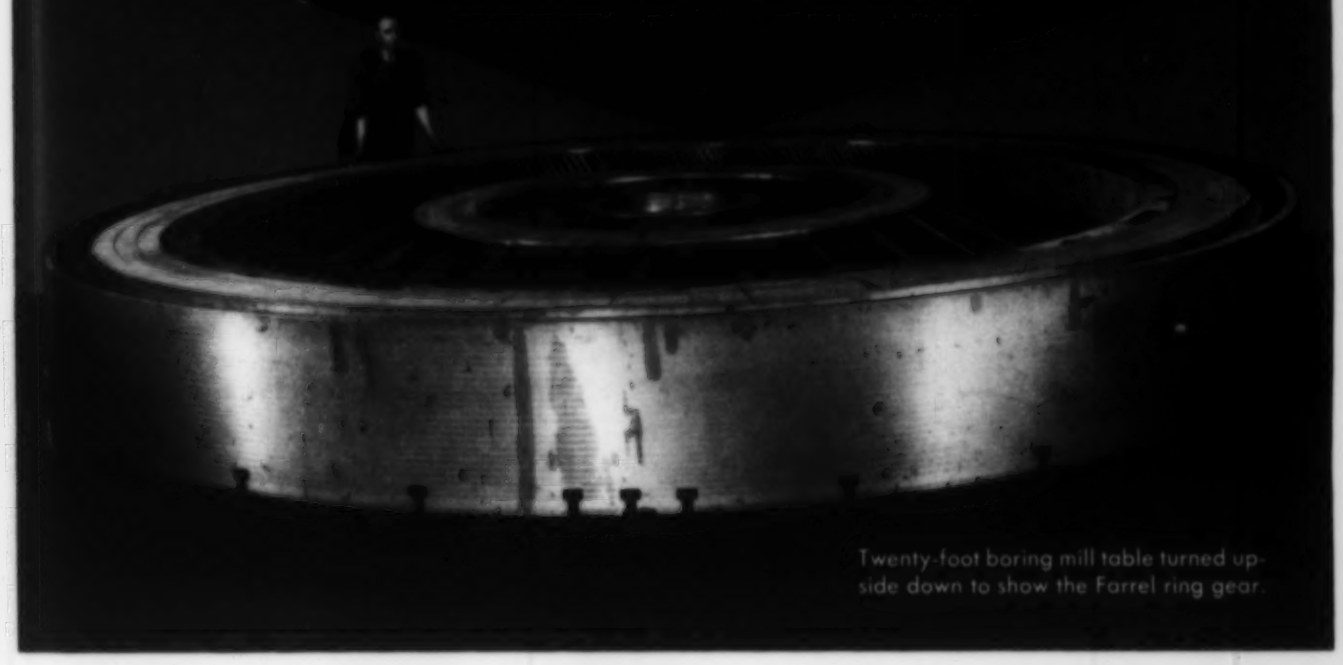
For more data circle MD-80, Page 215

Motorized Speed Reducers

Combination construction of 100 series Ratiomotors permits removal of motor without disturbing gear reduction unit. These standard stock motorized gear reduction units are also available without motor as flanged reducers. The 28 stock models which make up the series comprise 194 different motorized units, with general-purpose or totally-enclosed motors in 13 sizes from 1/6 to 10 hp. Ratio-

RATIOMOTOR
FLANGED REDUCTOR

FARREL RING GEAR



Twenty-foot boring mill table turned upside down to show the Farrel ring gear.

gives driving smoothness to boring mill table

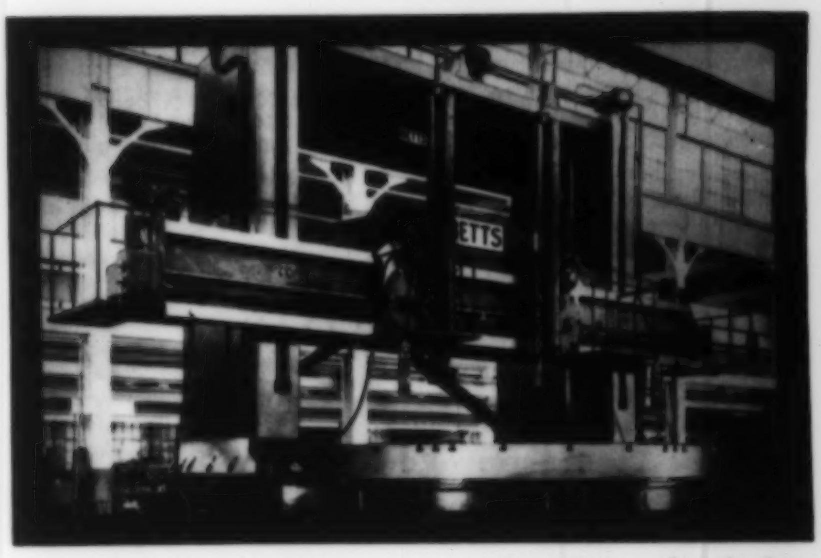
The huge single-helical ring gear built into this twenty-foot boring mill table is an important factor in obtaining an extremely fine finish on work turned on the mill.

Designed to impart driving smoothness to the table, both the gear and its mating pinion are precision generated by Farrel to a high degree of accuracy, and carefully fitted to eliminate the possibility of backlash. The pinion shaft is worm driven and this, together with the wide-angle helical gear, provides a smooth, chatter-free drive.

The gear, which is split, has a 30° right-hand helix angle, 276 teeth, 1½ DP. Its inside diameter is 183.294" and the face is 9¾" wide.

Farrel precision-generated internal gears are available with either helical or spur teeth in sizes up to 16 feet diameter, 12 inch face, ¾ DP. They are made of the finest grade materials.

Farrel engineers will be glad to assist you in working out unusual gear problems. Why not call on them?



The table is used on this Betts boring mill, made by Consolidated Machine Tool Corporation, Rochester, N. Y.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT

Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y. *Sales Offices:* Ansonia, Buffalo, New York, Boston, Akron, Detroit, Chicago, Memphis, Minneapolis, Fayetteville (N. C.), Los Angeles, Salt Lake City, Tulsa, Houston, New Orleans

FB-940

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Cambridge

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permit continuous washing, degreasing, quenching

Open mesh construction permits rapid drainage of process solutions, moving belt eliminates batch handling to provide continuous pickling, quenching, tempering, washing, degreasing. All-metal belt resists corrosion even under the most severe conditions.

In continuous heat treating installations Cambridge Woven Wire Conveyor Belts are impervious to damage at temperatures up to 2100°F. They have no seams, lacers or fasteners to wear more rapidly than the body of the belt . . . no localized weakening. Open mesh construction lets heat and gases circulate freely all around the work for uniform treatment.

No matter how you look at it, CAMBRIDGE Woven Wire Conveyor Belts are invaluable aids to AUTOMATION . . . eliminate profit-stealing batch and hand operations. They are made in any size, mesh or weave, and from any metal or alloy. Special raised edges or cross-mounted flights are available to hold your product during movement.

◀ Here's how a Cambridge belt permits CONTINUOUS WASHING. Stamping and drawing compounds, and metallic particles are washed through open mesh.

Call in your Cambridge Field Engineer to discuss how you can cut processing costs by continuous operation. You can rely on his advice. Write direct or look under "Belting, Mechanical" in your classified telephone book.

ASK FOR FREE 130-PAGE REFERENCE MANUAL illustrating and describing woven wire conveyor belts. Gives mesh specifications, design information and metallurgical data.

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CONVEYOR BELTS

The Cambridge Wire Cloth Co.

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OFFICES IN PRINCIPAL INDUSTRIAL CITIES

motor gear units less the motors are available in the same range with ratios from 10:1 to 3600:1 and output torque ratings from 50 to 9400 lb-in. Made by **Boston Gear Works,** 64 Hayward St., Quincy 71, Mass.

For more data circle MD-81, Page 215

Reversing Drum Switch

Usable for across-the-line starting and reversing of dc or single or poly-phase ac motors, size 1 drum switch is offered with either maintained-contact or spring-return-to-off. No tools are required for simple conversion. Switch has nylon shaft bushings and heavy plated copper contacts. Installation is facilitated by slip-on cover, pressure wire connectors, ample wiring space and easily accessible mounting holes. Made by **Square D Co.,** 4041 N. Richards St., Milwaukee 12, Wis.

For more data circle MD-82, Page 215

Nylon Molding Compound

Tradenamed Plaskon Nylon 8200, a new thermoplastic nylon compound is suitable for molding and extruding. Parts made from the material have high tensile

strength, good resistance to abrasion, heat and chemicals, high impact strength and are tough, lightweight and self-lubricating. Typical applications include gears, bearings, bushings, wire jacketing and cable coating, valves, instrument housings, and coil forms. Available from **Allied Chemical & Dye Corp.**, Barrett Div., Margaret and Bermuda Sts., Philadelphia, Pa.

For more data circle MD-83, Page 215

Rotating Swivel

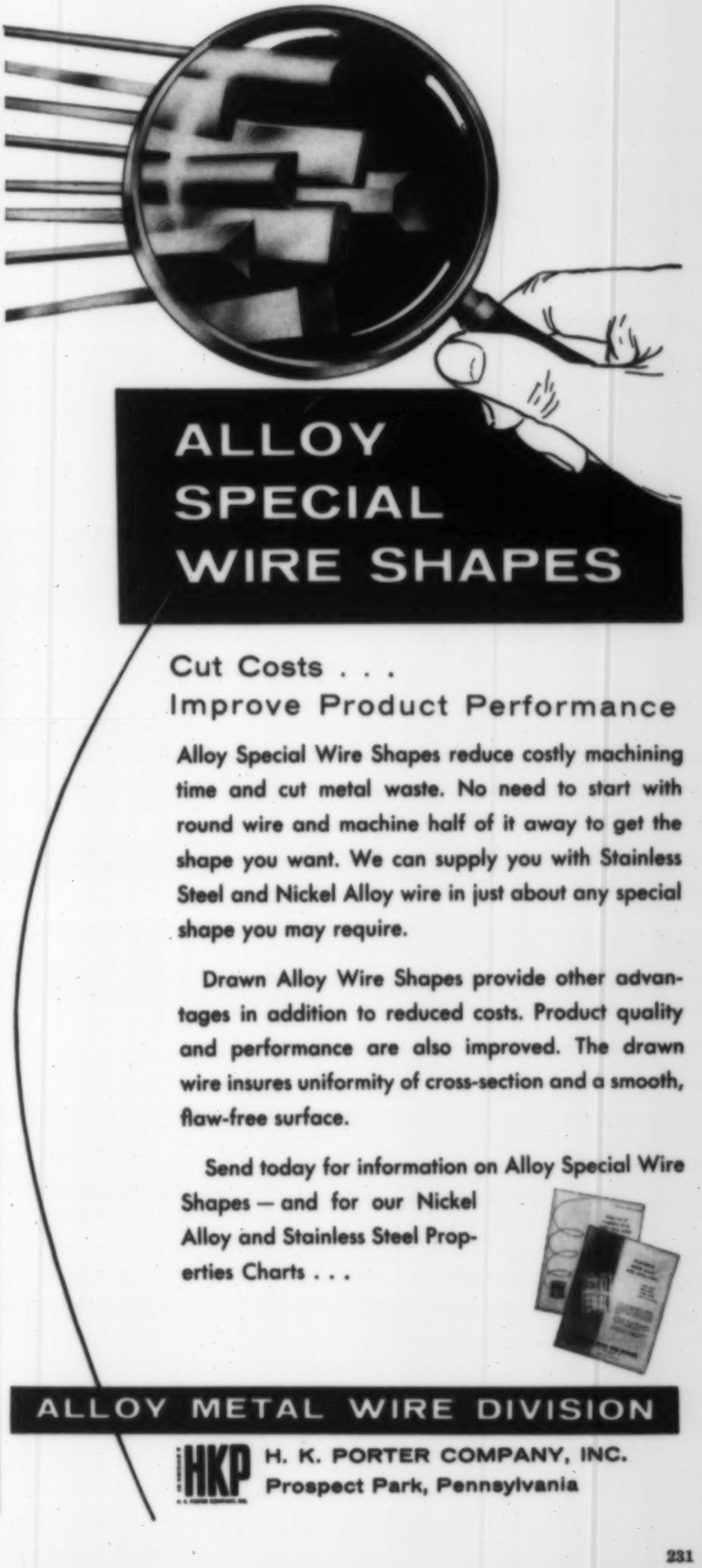
Built for high pressure and high operating speeds, this rotating swivel is equipped with spring-loaded Teflon rings, self-centering ball thrust bearings and efficient axial bearings. The compact model 4000 swivel, applicable to brake and clutch uses, measures only 3 x 1½ in. Made by **Hydraulic Unit Specialties Co.**, P. O. Box 172, Waukesha, Wis.

For more data circle MD-84, Page 215

Power Amplifier

P&H power amplifier provides variable dc power without the use of rotating parts. A self-contained unit, the amplifier provides variable speed, stepless control. Performance is similar to an adjustable voltage system. Input power can be any phase and voltage

(*Continued on Page* 234)



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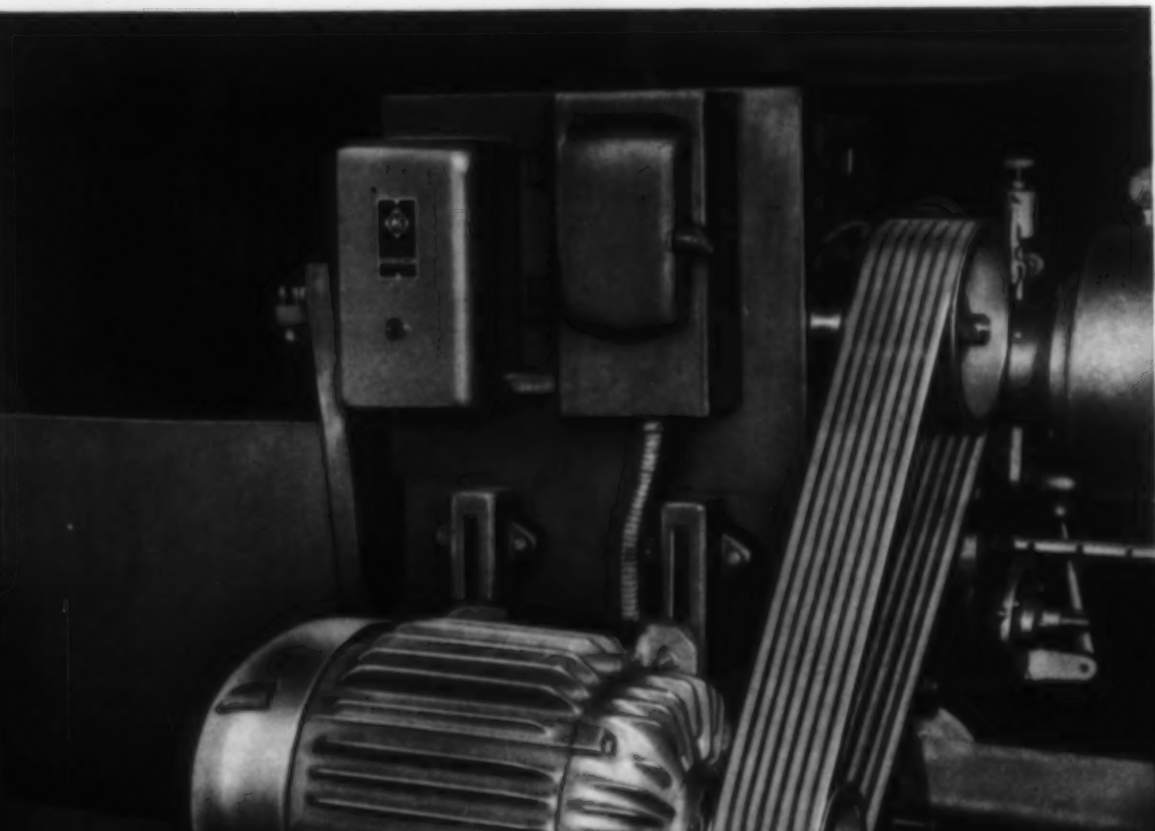

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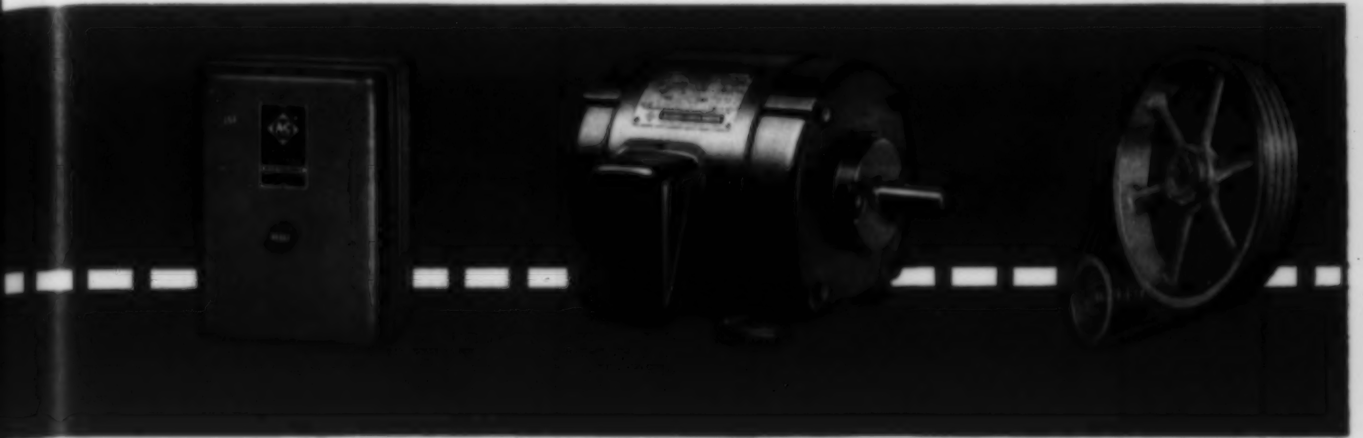

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RESISTS ABRASION

Amsco manganese steel's superior ability to resist wear partially results from its work-hardening characteristic. However, in tests where compression and shear stress have been applied *without impact* to a *non-work-hardened* specimen . . . it has shown abrasion resistance to wet #50 quartz sand in the range of 0.75 to 0.85 abrasion factor, (in comparison with SAE 1020 steel as 1.00).*

ADDITIONAL FEATURES

Amsco manganese steel is virtually nonmagnetic. It has a built-in safety factor resulting from its slow crack propagation rate, allowing early discovery of impending failure. Also, the metal retains its toughness even at arctic temperatures.

*This is a test where lower numbers infer superior abrasion resistance.

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AMERICAN MANGANESE STEEL DIVISION

AMERICAN Brake Shoe COMPANY

Chicago Heights, Illinois

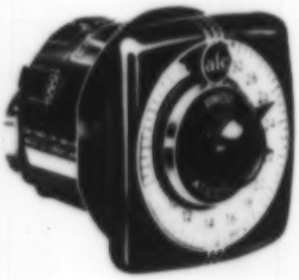
(*Continued from Page* 231)

combination. Control can be achieved electronically or by means of a simple rheostat or any other variable arrangement. Response is rapid. The amplifier is available in a wide speed range and in standard sizes from 1 through 30 hp. It can supply variable dc power to one or more motors up to the total of its capacity. Made by **Harnischfeger Corp.,** Electrical Products Div., 4621 W. National Ave., Milwaukee, Wis.

For more data circle MD-85, Page 215

Automatic Reset Timer

Timing and sequencing of electrical load circuits on industrial machinery and process operations are readily controlled with this Atcotrol automatic reset timer. It mounts in 3 3/16-in. round hole and is held in place by tension studs on a back-up ring held in position by an O-ring retainer. All parts are accessible for inspection without interrupting operation. Interchangeable, self-cleaning contacts are rated 10 amp at 115 v ac noninductive. Interchangeable dials and motors make possible ten timing ranges from 0-15 seconds with minimum setting of ¼-second to 0-240 minutes with minimum setting of 4 minutes. Made by **Automatic Temperature Control Co.,** 5200 Pulaski Ave., Philadelphia 44, Pa.



For more data circle MD-86, Page 215

Reversible Synchronous Motor

Circle B series 430 reversible synchronous motor develops high starting and synchronous torque and provides adequate torque for high-speed operation. Torque is

Do You Want To Save Horsepower and Heat?

VICKERS

Two-Pressure Oil Hydraulic Pumps Require Less Power for Two-Pressure Circuits

Automatically Provide

High Volume @ Low Pressure for fast closing, rapid advance, and rapid return.

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Low Volume @ High Pressure for feeding, compressing, clamping, and holding.

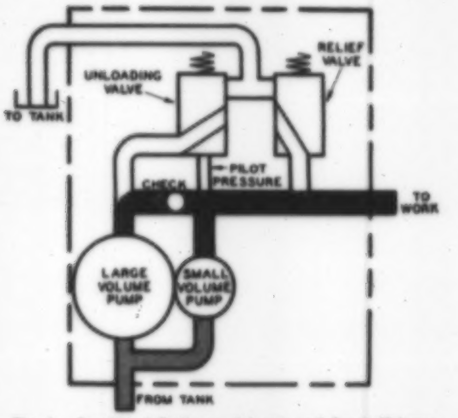

Fig. 1 Combined Delivery of Large and Small Volume Cartridges at Low Pressure

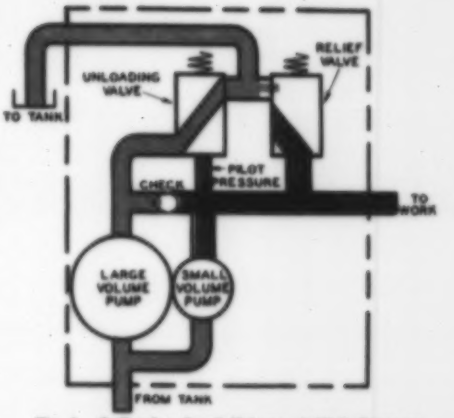

Fig. 2 Delivering Small Volume at High Pressure

Two Vickers Vane Type pumping cartridges are mounted on the same shaft—in the same housing, driven by the same prime mover. One provides a large volume of oil while the other delivers a small volume. These Vickers Two-Pressure Pumps have proved advantageous in a wide variety of applications.

For example, in closing a press or in rapid advance, both pump cartridges work together, supplying maximum volume for quick operation (see Fig. 1). When the press is closed and compression begins, or when the tool goes into feed immediately prior to beginning the cut, the large volume cartridge is automatically unloaded to the reservoir at zero pressure (see Fig. 2). The small volume cartridge alone then provides the lower volume required at high pressure.

These Vickers Two-Pressure Pumps are most economical in power consumption for such two-pressure operation. The reason for this is that a small-volume pump working at full capacity is MORE EFFICIENT than a large-volume pump working at partial capacity. Regardless of momentary delivery, the internal leakage of any pump is proportional to its size and operating pressure. The chart (Fig. 3) shows an interesting comparison between a Vickers Two-Pressure (Two-Volume) Pump and a variable volume vane type pump on a press circuit.

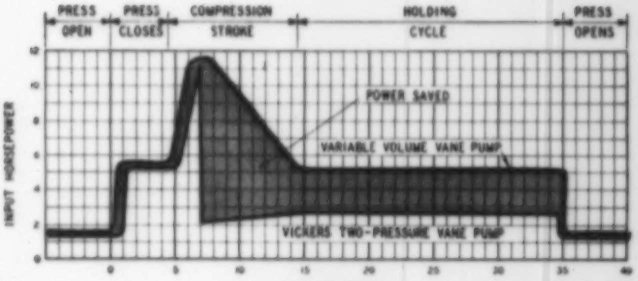

Fig. 3. On this typical press application the saving in power is approximately 50% with a resultant saving in heat in the system.

Like all Vickers Vane Pumps, these two-pressure pumps have the hydraulic balance feature that relieves bearings of all pressure loads (one of the major causes of wear). Cartridge construction enables customer to service in his own plant instead of returning to factory should repairs be necessary. Relief and unloading valves are integral . . . minimizing piping and connections. Complete range of sizes up to 48 gpm. For additional information, ask for Bulletin 54-70a.

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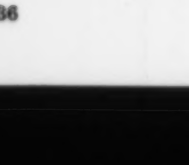


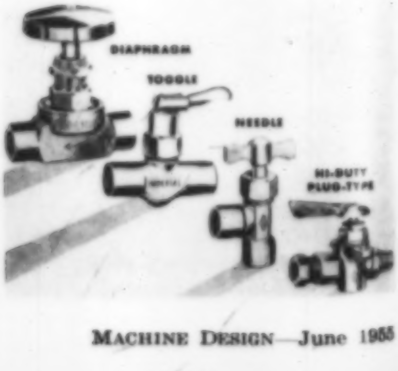
Also manufacturers of NYLINED Bearings — DuPont NYLON within a metal sleeve—for rotation and reciprocation.

5 lb-in. at 1 rpm when motor is operating on 115-v, 60-cycle current. Reversibility of motor makes it adaptable for remote control applications as well as a variety of other industrial uses. Operating speed ranges from 10 revolutions per hour to 1800 rpm. Any one of a variety of output shafts is available. Overall size of motor is 2 x 2 x 2 in. Made by **Vocaline Co. of America Inc.**, Bristol Motor Div., Old Saybrook, Conn.

For more data circle MD-87, Page 215

Fluid Control Valves

Line of fluid control valves includes types for both panel mounting and in-line service. Needle valves for accurate regulation of flow have O-ring seals, 5/16-in.-32 pitch single lead threads, and pressure range to 500 psi. Sizes are ⅛ and ¼-in. Toggle valves for quick opening and closing also have O-ring seals and synthetic rubber seats. They are spring-closing, while lifting lever opens valve. Maximum pressure is 200 psi in ⅛ and ¼-in. sizes. Packless two and three-way valves have Teflon diaphragms for pressure up to 300 psi and temperatures from −100 to 450 F. Especially adapted for vacuum service, valves range in size from ⅛-in. female pipe thread to ¾-in. flare connections and ⅞-in. OD solder connections. Two,



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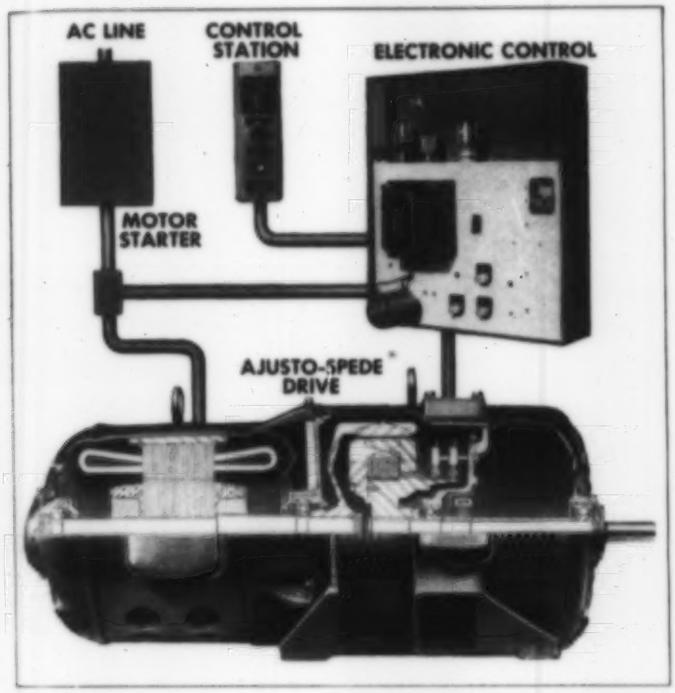

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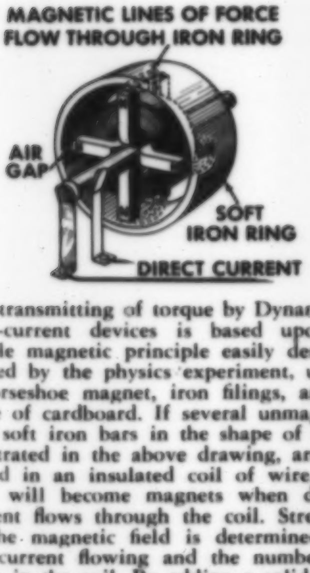
Increased production, reduced costs, improved quality of product, and more complex processing techniques demand an ever increasing use of stepless adjustable speed drives. Dynamatic eddy-current equipment in one form or another attains these objectives.

Dynamatic Ajusto-Spede® Drives, Air and Liquid Cooled Couplings, Air and Liquid Cooled Brakes, Absorption, Motoring, and Universal Dynamometers operate on the same basic electro-magnetic principle.

A typical installation pictorially illustrates the simplicity and minimum components required to obtain controlled adjustable speed.

Basic Principles of Operation



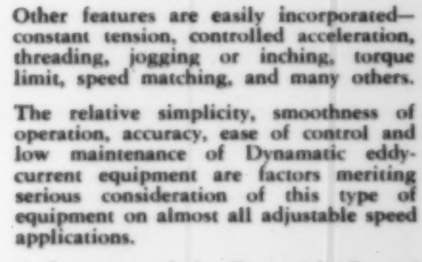
The transmitting of torque by Dynamatic eddy-current devices is based upon a simple magnetic principle easily demonstrated by the physics experiment, using a horseshoe magnet, iron filings, and a piece of cardboard. If several unmagnetized soft iron bars in the shape of a U, illustrated in the above drawing, are inserted in an insulated coil of wire, the bars will become magnets when direct current flows through the coil. Strength of the magnetic field is determined by the current flowing and the number of turns in the coil. By adding a solid ring of soft iron, encircling the poles of the electromagnets, the magnetic lines of force will flow through the ring. The basic construction of all Dynamatic eddy-current rotating equipment is then simulated.

The illustration shows magnetic lines of force with no relative rotation between the ring and magnets. When the field assembly (magnets and coil) is rotated mechanically, the iron ring separated from it by a nominal air gap remains stationary until current is applied to the coil. With the coil energized, mechanical rotation of the magnets produces movement of magnetic flux in the ring, creating eddy-currents in the ring. These induced currents develop a second magnetic field. Its strength is determined by the strength of the primary field and the relative speed difference (slip) between the two members. In the eddy-current coupling, attraction of these two fields cause the ring to follow the field magnets in rotation. When the coil current is varied, the eddy-currents will be proportionately affected, and torque produced at the output shaft will be similarly changed.

A typical eddy-current coupling torque curve with rated excitation and additional curves with reduced excitation is shown. In the same figure, a constant torque and fan torque load curve is plotted. Excess torque, which is a measure of accelerating capacity, is indicated. The Dynamatic coupling transmits this torque from a driving member, that may be either the drum ring or field magnets, to a driven member without mechanical contact.

Because of the extremely small excitation requirements, Dynamatic units lend themselves readily to electronic or magnetic amplifier control.

By taking advantage of the very high amplification factor of these controls, the largest couplings can be easily and conveniently controlled with a small adjusting potentiometer. The voltage output of a permanent magnet alternator mounted on the coupling output shaft varies directly with the shaft speed. This variable voltage signal modulates the control, automatically maintaining the selected speed of the coupling output shaft, within close limits, over a wide speed range.



Other features are easily incorporated—constant tension, controlled acceleration, threading, jogging or inching, torque limit, speed matching, and many others.

The relative simplicity, smoothness of operation, accuracy, ease of control and low maintenance of Dynamatic eddy-current equipment are factors meriting serious consideration of this type of equipment on almost all adjustable speed applications.

A free copy of the Dynamatic General Bulletin describing eddy-current equipment in more detail is available. Write for your copy.

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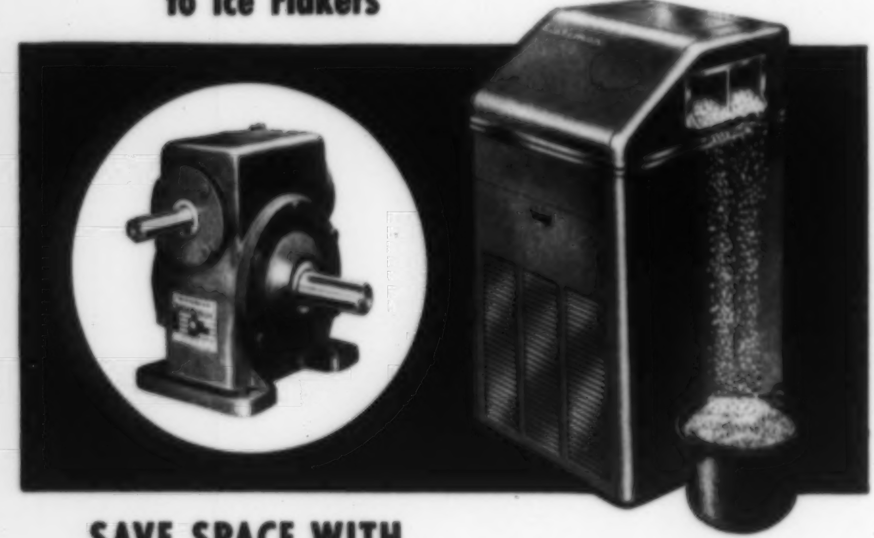

SAVE SPACE WITH
WINSMITH
SERIES "C" SPEED REDUCERS!

For *every* speed reducer application where space is at a premium, you'll put a premium on the new Winsmith Series "C" Speed Reducers. With this series, Winsmith achieves stepped-up horsepower and torque output without increase in overall size. Pricewise, this means that the "C" Series Reducer gives you more value than ever offered for your horsepower dollar.

The streamlined Scotsman Ice Flaker, manufactured by the American Gas Machine Company, is an example of how one manufacturer uses Series "C" Reducers to make every inch of space count. Because of *compactness*, the model "CT" reducer has been selected for use on the complete Scotsman Line. And, equally important, — *trouble-free operation* — is another reason the American Gas Machine Company gives for selecting this series!

Driven by a ¼ hp motor at 1725 rpm, with a reduction ratio of 49 to 1, these "CT" reducers are helping to build a splendid reputation for Scotsman Ice Flakers in thousands of restaurants, hotels, hospitals and institutions throughout the country.

Whatever your products may be — from drying ovens to ice flakers — if you're designing for more streamlined appearance, or, if you're aiming at reducing component size without sacrificing performance, then you should get the complete facts on the Winsmith Series "C" Reducers. Write today for Bulletin HW-654.

This view of the mounting arrangement in the Scotsman Ice Flaker, shows the 10" pulley attached to the high speed shaft of the reducer.

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16 Elton Street
Springville (Erie County), N. Y.

WINSMITH
SPEED REDUCERS

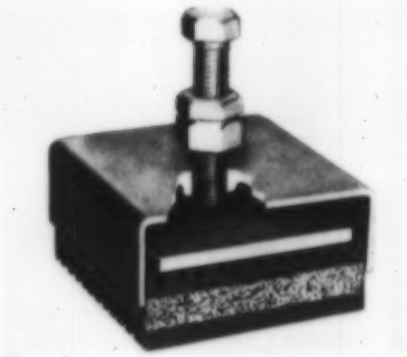
...a single source for the most complete line of speed reducers within the range of 1/100 h.p. to 85 h.p. in ratios of 1.1:1 to 50,000:1

three and four-way Hi-Duty plug type shut-off valves are offered in range of end connections for pipe sizes from ⅛ to ⅜-in. and tubes from ⅛ to ½-in. OD. Made by **Imperial Brass Mfg. Co.**, 1200 W. Harrison Ave., Chicago 7, Ill.

For more data circle MD-88, Page 215

Vibration Dampener

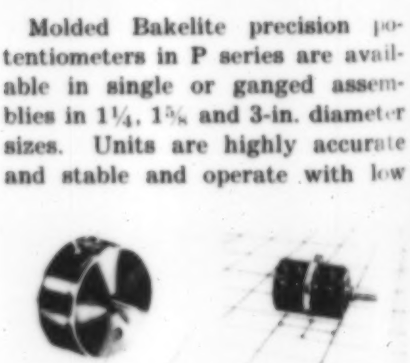
Lev-Elasto adjustable leveling mount dampens vibration and isolates shock, yet does not require anchor bolts or shims. Easily and quickly installed, it prevents machinery from walking. Elasto-Rib isolating medium of cork and neoprene will not pack down or become deteriorated by oil or chemicals. Sizes for various loading conditions are available with ⅝-in. adjustment. Made by **Korfund Co.**, 48-19D 32nd Pl., Long Island City 1, N. Y.



For more data circle MD-89, Page 215

Potentiometers

Molded Bakelite precision potentiometers in P series are available in single or ganged assemblies in 1¼, 1⅝ and 3-in. diameter sizes. Units are highly accurate and stable and operate with low



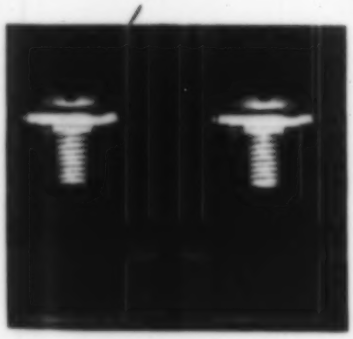
New!

Two-pole common-trip Quicklag® breakers —"bolt-on" or "plug-in"

Whatever your choice of mountings, the new Westinghouse two-pole, common-trip Quicklag circuit breaker can now give you more flexible and efficient protection for small-wire general lighting and branch circuits. Available in 15-50 ampere ratings—120/240-volt—for a-c circuits in loadcenters, panelboards, individual applications.

Common-trip bar opens both poles simultaneously with an overload on any one pole. Single handle indicates "trip", "on" or "off". All ratings listed by Underwriters' Laboratories, Inc.

Thermal-magnetic tripping elements, De-ion® arc quenchers, a proven quick-make, quick-break mechanism, and non-welding silver alloy contacts—all combined in electrically isolated compartments—assure protection against small overloads, instantaneous magnetic action against short circuits, and longer operating life. Call your Westinghouse representative, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-30184



"Bolt-on" type breaker completes the Westinghouse Quicklag line—offers a two-pole Quicklag breaker for every application.

"Plug-in" type breaker is firmly gripped by a female line terminal clamp plus pressure contacts on the load end of the breaker.

YOU CAN BE *SURE*...IF IT'S

Westinghouse

AVON

Fusionweld

STEEL TUBING

IT'S TOUGHER • MORE DUCTILE • SMOOTHER • MORE ECONOMICAL TO FABRICATE

Fusionweld IS TOUGHER . . . Avon's own exclusive high frequency resistance welding method produces an entirely new uniformity of grain structure in the welded and adjacent wall area by means of an advanced type of electronic control. This exclusive process combined with our improved cold drawing of larger size tubing into smaller diameters is responsible for the extremely smooth surface finish, closer diameter tolerances and new ease of fabricating.

Fusionweld HAS A PERFECTED SINGLE WALL CONSTRUCTION . . . Avon is able to offer thin wall tubing as a highly impressive substitute for costlier tubing—both ferrous and non-ferrous—because of its hi-cycle method of controlled welding. This tubing is available in three tempers—"as welded," "as drawn" and annealed to insure the last word in adaptability to varied tubing uses. It is more economically fabricated—takes tougher bends, beads, flares, etc.—withstands pressures up to 18,000 PSI—has no equal in resisting the severest types of fatigue from vibration.

Fusionweld IS EASIER TO FABRICATE . . . Avon's exclusive tube making process has proved itself, matching the most difficult forming operations, with a higher degree of ductility and tensile strength to insure new fabricating ease, lower scrap loss, greater performance reliability. Today our mills are successfully producing over 7½ million feet per month for hundreds of important tubing applications. Our sales engineering staff will gladly assist you . . . or send us your blue prints for tube quotations.

•

3/16" O.D. to 3/4" O.D.
PLAIN OR TERNE COATED

AVON TUBE DIVISION
HIGBIE MANUFACTURING CO.
ROCHESTER MICHIGAN

noise, low torque, minimum distributed capacity and good frequency response. Mounting of the two smaller models is by means of threaded bushings. A precision pilot is available for servo applications. Three tapped holes are provided for mounting the largest model. An additional flange is available for optional precision pilot. Made by **Technology Instrument Corp., Acton, Mass.**

For more data circle MD-90, Page 215

Machine Control Panels

Series LA, LB and LD control panels provide rapid traverse forward, either one or two adjustable forward feed rates depending upon model, and rapid return. Maximum operating pressure is 1000 psi. Units have ½ and ¾-in. IPS fittings for volumes up to 20 gpm.

They are available either electrically operated or with electrically operated reversing control and cam operated feed selector. Electrical portion of panels is solenoid control pilot. Design prevents rapid traverse forward or rapid return out of cycle if a solenoid should burn out. Feed rates are adjustable from 10 cu in. per minute to 4.2 gpm. Made by **Double A Products Co., Manchester, Mich.**

For more data circle MD-91, Page 215

Transducer

The Microformer is a miniature variable output transformer used to measure small displacements. It consists of three coils of wire wound coaxially on a ceramic or plastic spool with an axial hole for a movable magnetic core. The

(*Continued on Page 244*)

New Westinghouse control relays

for pilot circuits, automatic control and sequencing operations

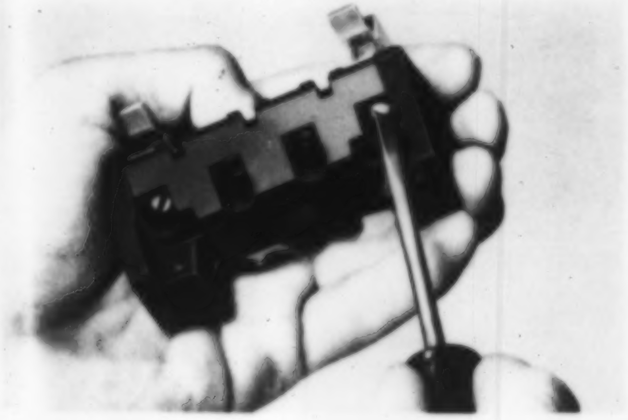
Specially designed friction-free bearings—exclusive with Westinghouse—eliminate sticking or jamming and sliding wear. That's why the new Westinghouse control relays are *always* dependable—stay on the job longer.

Designed particularly for any circuits involving rapid openings and closings. Positive action, kick-out spring provides rapid, dependable operation.

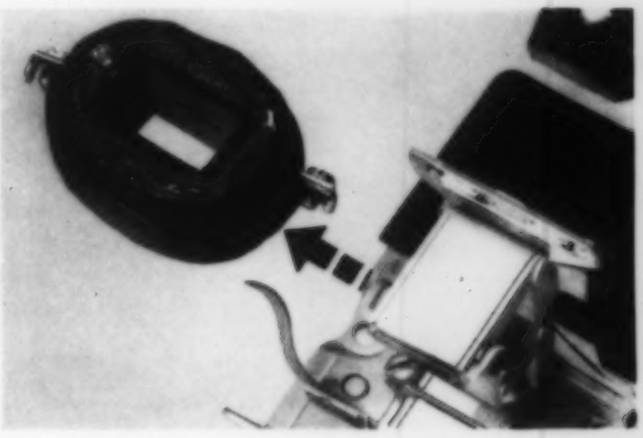
Rated at 10 amperes (open). Available in any combination of normally open or normally closed contacts; 2, 3, 4 or 6 pole for any voltage up to 600 volts a-c; and either open or in standard NEMA enclosures for specific applications.

For *all* the facts, call the control sales engineer at your nearest Westinghouse office, *The Man With The Facts!* J-30187

YOU CAN BE **SURE**...IF IT'S
Westinghouse



Easier Contact Changes . . . Switch from normally open position to normally closed position, or vice versa, easily made in the field. All you need is a standard screw driver—there are no parts to add or any wires to disconnect.



Easily Accessible Parts . . . Removing the magnet coil from the relay is quickly accomplished as evidenced by the above photograph of the magnet coil and retaining spring. All other parts are equally accessible—easy to get at.

POWER
TAKE-OFF

Twin Disc Power Take-Offs are available with clutches ranging from 6.5" to 24" single-plate; from 11.5" to 24" double-plate. Housing sizes No. 6 SAE to No. 00 SAE. Capacities up to 600 hp. Write for Bulletin No. 129-C.

Next time you're watching powered equipment driving through a friction power take-off, check the name plate on the drive back of the engine. In all probability, you'll see a Twin Disc Power Take-Off, putting *more horsepower to work.* With their simple, *rugged* design—single-point adjustment—and slippage capacity far in *excess* of horsepower rating, ***Twin Disc Power Take-Offs are selected as standard equipment by most of the nation's leading industrial engine manufacturers.***

That's why you'll find Twin Disc Power Take-Offs on such leading industrial engines as Ajax - Buda - Caterpillar - Climax - Continental - Cummins - Hercules - International - LeRoi - Minneapolis-Moline - Murphy - Superior - Waukesha - White - Wisconsin . . . for these manufacturers know they can depend on Twin Disc performance . . . and they know, too, that wherever their engines may be ultimately working, Twin Disc Service will only be a matter of hours . . . backed by 60 Parts Stations and 8 Factory Branches or Sales Eng. Offices.

TWIN DISC

TWIN DISC
Friction Clutches and Fluid Drives

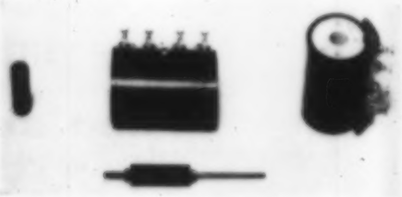
TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

Branches or Sales Engineering Offices: Cleveland • Dallas • Detroit • Los Angeles • Newark • New Orleans • Seattle • Tulsa

New Parts

(*Continued from Page 240*)

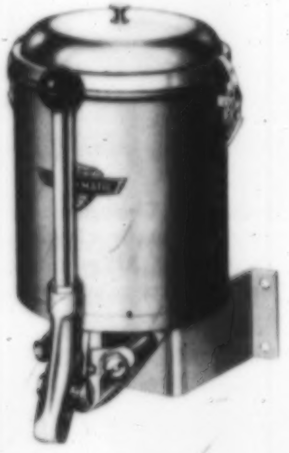
central coil is the primary and the outer coils, connected in series to oppose each other, are secondary. An outer iron cover provides magnetic shielding. Displacement of the core either way from the neutral electrical center of the energized primary coil results in an output voltage that is a linear function of core displacement. Primary voltage is normally 10 v or less. Standard size Microformer has a maximum core travel of 0.12-in. It is 1½ in. long and ⅞-in. in diameter. Core travel of a smaller size unit is 0.06-in. Units are mounted by means of tapped holes, screw lugs or flat lugs. Made by **Baldwin - Lima - Hamilton Corp.**, Philadelphia 42, Pa.



For more data circle MD-92, Page 215

Lubrication System

This high-pressure centralized system lubricates bearings while machine is operating or while it is idle. A few strokes of the manually operated pump handle force lubricant under 2500 psi pressure through a single line circuit of injectors or adjustable force-feed measuring valves, one of which is provided for each bearing. A measured quantity of lubricant is delivered to each bearing every

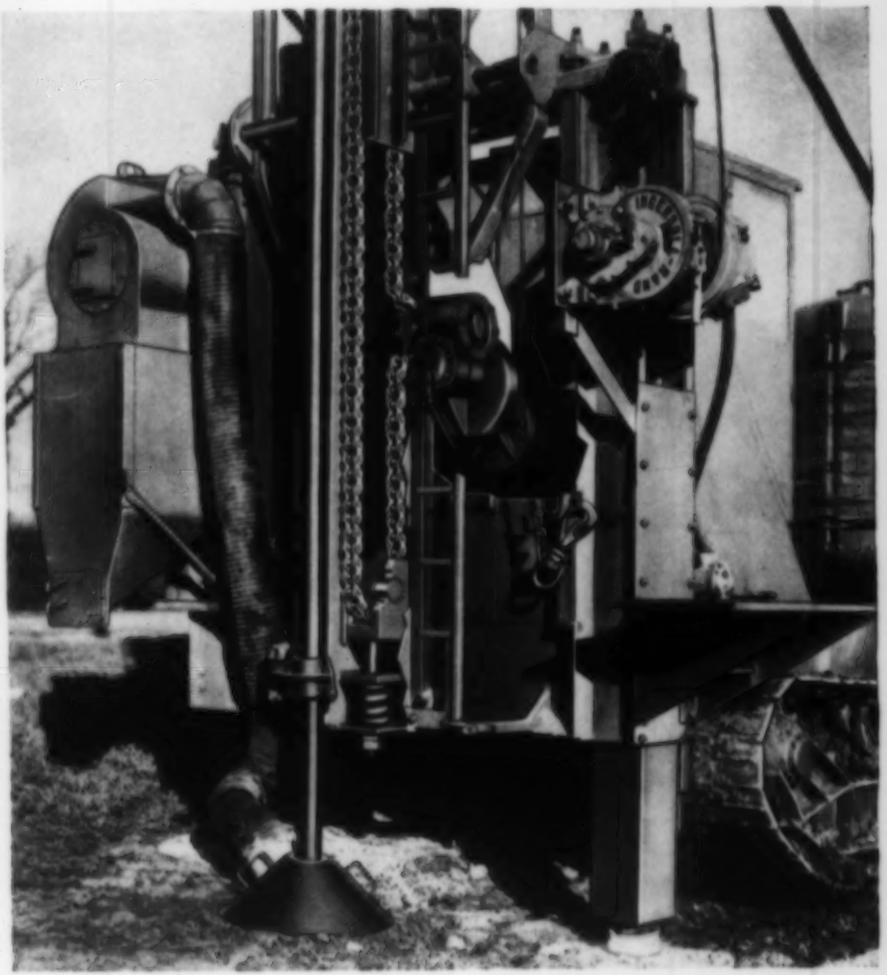


These LINK-BELT Roller Chain EXTRAS put more life into your machines

LOCK-TYPE BUSHINGS (applied on a range of sizes) end a common cause of stiff chain.

PRE-STRESSING of multiple width chain provides uniform load distribution.

SHOT-PEENED ROLLERS have greater fatigue life, added ability to withstand impact.



Ingersoll-Rand uses Link-Belt Precision Steel Roller Chain for positive drill feed on their Quarrymaster primary blast-hole drill.

THROUGHOUT every stage of manufacture, Link-Belt takes *extra* care to build *extra* life into Precision Steel Roller Chain. Shown above are three of these added refinements . . . and there are many others which contribute to better performance and longer life for your machines.

You can choose from a wide range of Link-Belt roller chains and sprockets. In addition, Link-Belt's complete line includes silent chain drives . . . and all sizes and types of cast, combination, forged and fabricated steel chain.

Data Book 2457 will aid you in selecting and ordering roller chain. Get your copy from the nearest Link-Belt office now. And remember to see Link-Belt for all your drive and conveying chain needs.

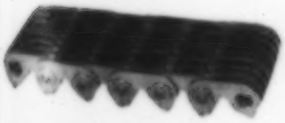
LINK-BELT

CHAINS and SPROCKETS

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

13,720

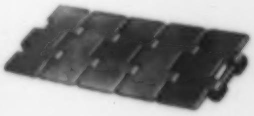
No one chain serves every purpose . . . get the RIGHT one from Link-Belt's complete line



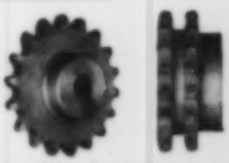
Silent Chain

LXS Steel Chain

Detachable Steel Link-Belt



S-815 Flat-Top Chain



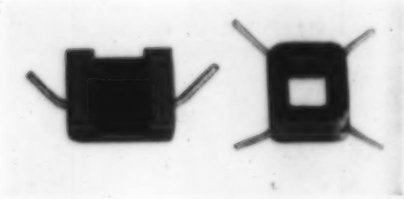
Cast and Cut-Tooth Sprockets

time the system is cycled, and an indicator shows when the cycle has been completed. Release of the pump handle automatically vents and recharges the system. Reservoir accommodates 15 lb of grease or oil. Made by **Lincoln Engineering Co.,** Industrial Div., 5736 Natural Bridge Ave., St. Louis 20, Mo.

For more data circle MD-93, Page 215

Molded Coil Windings

Luxolene coils, molded from epoxy resins, are impervious to water, oils, dust, acids, alkali solutions and water-base hydraulic fluids. The core tube is fabricated from the same resin as is used in encapsulating the windings; thus a complete homogeneous bond is provided on all external surfaces. Material will not separate during thermal cycling. Hermetic sealing is provided where leads emerge from coils. Windings are molded in green, black, red and blue, and all four colors are recognized by Underwriters' Laboratories as insulating materials for general purpose applications, meeting 105 C class A requirements. Shrinkage factor is very low and dielectric value is 1800 v per mil. Made by **DeLuxe Coils Inc.,** Wabash, Ind.



For more data circle MD-94, Page 215

Polyphase Motors

Equipped with corrosion resistant cast iron frames, type DP general purpose ball-bearing polyphase motors are suitable for indoor or outdoor use. Smooth contours of frames prevent collection of moisture on the surface. Ventilating air intakes, located at the bottom of endplates, and air outlets at the base of the frame on each side protect motors from moisture. Motors are dripproof. Rerated NEMA

Attention: Executive in charge of getting the JOB DONE!

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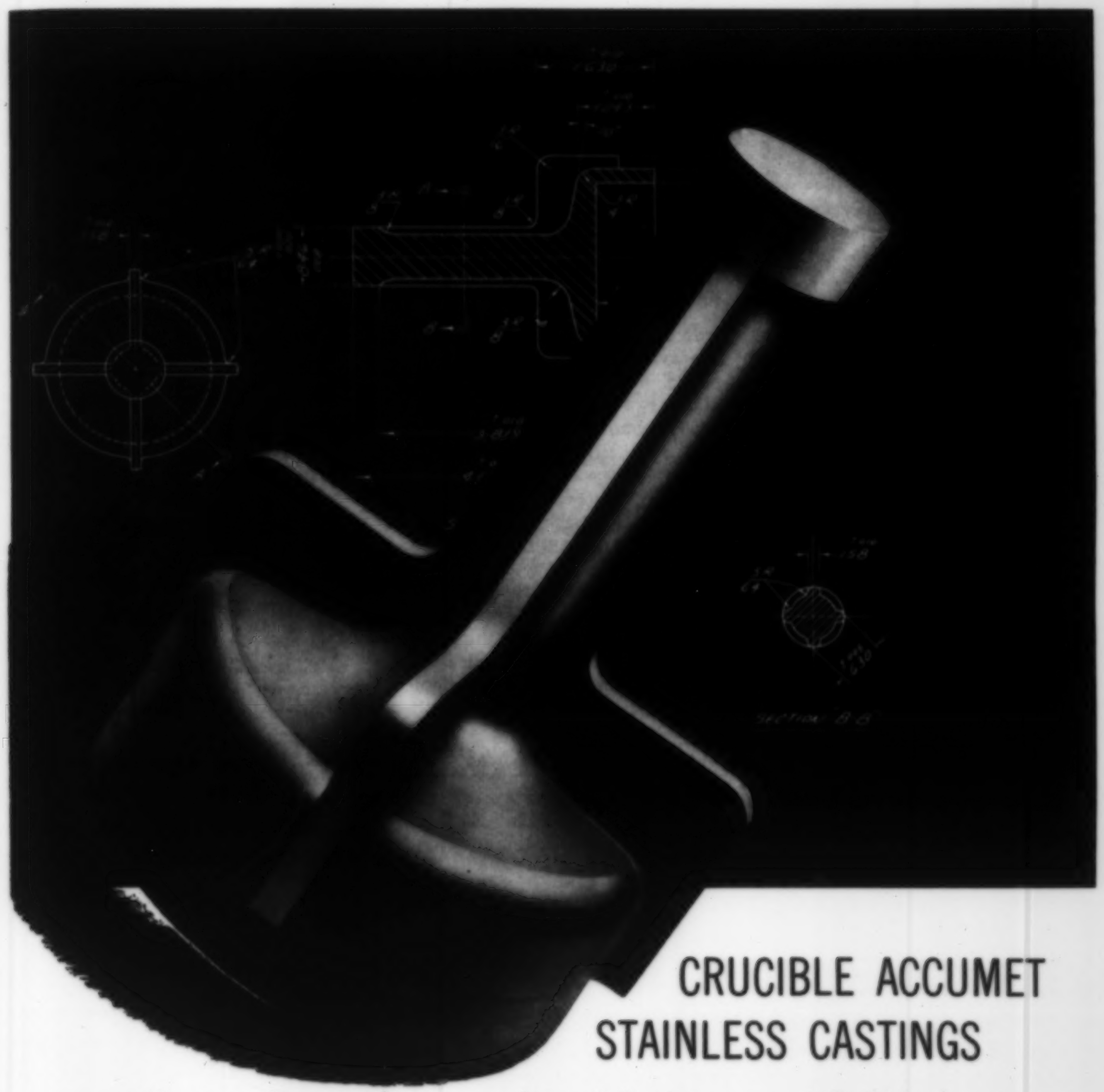


CRUCIBLE ACCUMET STAINLESS CASTINGS

provide smoother surfaces . . . closer tolerances — cut finishing costs

Even intricately shaped parts, like this cream separator neck piece, can be used essentially as-cast when produced by the ACCUMET method. That's because ACCUMET casting employs hot molds with special inner linings. You get castings on which thin sections are minutely defined . . . and with exceptionally fine surface finish. *Costly finishing operations are practically eliminated.*

On this stainless steel part, for example, the only finishing operations necessary are drilling and tapping of the stem section, grinding flats on the bow end, and polishing.

To minimize finishing operations on your products, consider the advantages of ACCUMET precision investment castings. Let your Crucible representative show you how their close tolerances, fine finish, and physical and metallurgical accuracy can spell substantial savings for you. And — to see what information is available on these and other Crucible special steels, write for your free copy of the "Crucible Publication Catalog." *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE **first name in special purpose steels**

Crucible Steel Company of America

GUARANTEED
RIGHT ANGLE
POWER TRANSFER

CROWN
MITRE GEAR UNITS

. . . transfer power at 90° angles . . . "guaranteed to give satisfactory service" when used with correctly rated motors, for example, 1/3 H. P. Crown Gear Unit with 1/3 H. P. motor.

Ideal for all types of right angle problems, Crown Gear Units are compact, rugged and engineered for *industrial* use. Completely enclosed, the Crown Mitre Gear has a convenient lubrication port, and provides four or five mounting flanges.

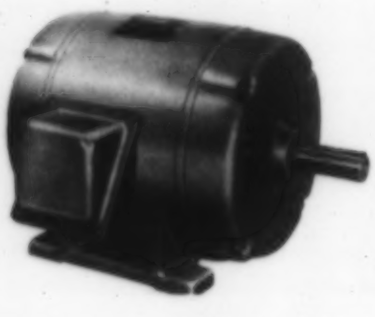
Special models will be engineered and quotations submitted for any specific problem. Crown Gear Units are available almost everywhere. — Write today for your distributor's name, or engineering details.

CROWN
GEAR

a division of Harrington & Richardson, Inc.
320 PARK AVENUE, WORCESTER 10, MASS.

Over 120 leading distributors in 43 states, Crown Mitre Gear Units are where you want them . . . when you want them.

Sold in Canada by H. & R. Arms Co., Ltd., Montreal 23, P. Q.

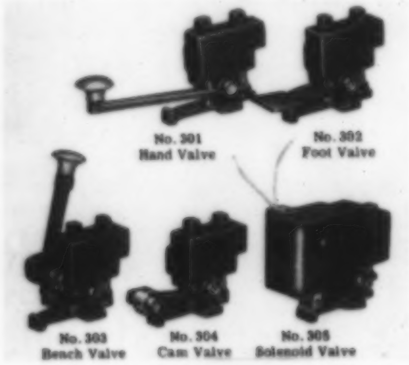


frame sizes from 182 through 326 are available in 1 to 30-hp, three-phase, 60-cycle, 1750-rpm ratings. Made by **Wagner Electric Corp.**, 6400 Plymouth Ave., St. Louis 14, Mo.

For more data circle MD-95, Page 215

Air Valve Assembly

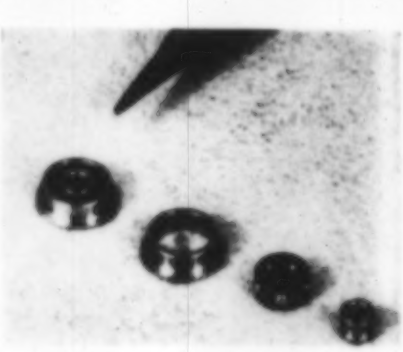
Basic 300 series valve assembly can be used as a spring-return hand valve, spring-return foot valve, self-locking bench valve, spring-return cam valve or solenoid-actuated valve. A built-in speed control regulates a double-acting cylinder in both directions. Actuating levers are interchangeable, and valves have two large plugs for easy cleaning and parts replacement. Valve base and body is an aluminum casting; seals are Neoprene; and springs and plungers are bronze, brass or stainless steel. Made by **Mead Specialties Co.**, Dept. SV-25, 4114 N. Knox Ave., Chicago 41, Ill.



For more data circle MD-96, Page 215

Miniature Ball Bearings

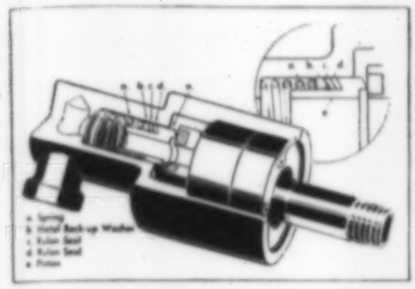
These separable miniature ball bearings are designed for easy assembly and high-speed applications. Flanged to facilitate assembly without counterboring, the magneto type bearings support both radial and thrust loads in blowers, gyros, spin motors and other mechanisms. Radial support of a shaft mounted in the bearings is not affected by slight axial play. Two bearings mounted in opposition control internal bearing clearance by axial adjustment. Brass, stainless steel or vacuum impregnated phenolic plastic retainers withstand temperatures to 200 F and over. Bearings are manufactured to ABEC 5 tolerances in either SAE 52100 chrome bearing steel (60 Rockwell C minimum) or 440 stainless (56 Rockwell C minimum) and are assembled with either inner or outer race relieved. Four standard sizes are available, ranging from 0.0550 to 0.1250-in. bore size and 0.1875 to 0.3125-in. OD. Illustration shows, from left to right, assembled bearing and components, consisting of flanged outer ring, balls with laminated phenolic retainer, and inner ring. Made by **Miniature Precision Bearings Inc.**, Keene, N. H.



For more data circle MD-97, Page 215

Rotary Joint

Sealing at temperatures up to 550 F is possible with the Anco improved low pressure rotary joint. Redesigned piston and piston seal with increased sealing contact surfaces make high temperature use possible. Formed shape of Rulon, a low friction bearing material, is fitted to the piston and maintained under pressure by the sealing spring and line pressure. Balanced piston makes use of line pressure to control unnecessarily high pres-



sure against rotating sealing surfaces. Joint has self-adjusting wear take-up and is leakproof hot or cold. Made by **American Associates Inc.**, Anco Div., 1 Baker St., Providence 5, R. I.

For more data circle MD-98, Page 215

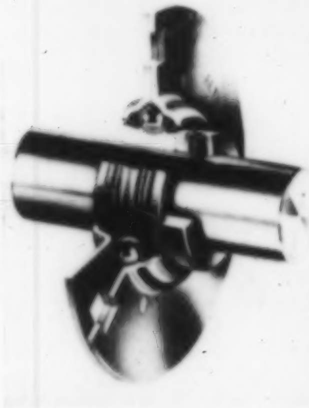
High-Wattage Rheostats

Spring in contact arm provides these high-wattage rheostats with automatic adjustment of brush pressure over the entire contact area of the winding. Rated at 225, 300, 500, 750 and 1000 w, they incorporate high-strength, corrosion-resistant alloy terminals, high-temperature enamel, a tripod mounting frame and "bus bar" brush construction which affords maximum current-carrying capacity and minimum resistance to collector ring. Rheostats conform to current standards of military specification MIL-R-22, RETMA, NEMA and Underwriters' Laboratories. All five models are available in wide rating ranges. Made by **Hardwick, Hindle Inc.**, 40 Hermon St., Newark 5, N. J.

For more data circle MD-99, Page 215

Shaft Bearing Support

Designed for shafts supported by sheet metal members, this prelubricated adapter bearing handles relatively light loads and slow speeds. A flange, which actually is the outer bearing race, is bolted in place and the shaft is slipped through and secured by an eccentric locking collar. Maximum capacities are 1000 rpm and loads of 200 lb. Flexible self-contouring grease-resistant seal provides a permanent, positive contact. Self-aligning bearing compensates for mounting inaccuracies, shaft or structural member deflections and misalignment up to ⅛-in. per foot. Made by **Aetna Ball & Roller Bearing Co.**, 4600 Schubert Ave., Chicago 39, Ill.



For more data circle MD-100, Page 215

Circuit Breaker

Designed for incorporation in appliances and other small electric equipment, these Mini-Breakers are engineered for single-hole mounting. Terminals accept AMP Faston or similar connectors. Model MP-252 furnishes permanent push-button primary circuit protection for 15, 20 and 30-amp loads, while the model MP-600 is designed for 4 to 30-amp secondary circuits. Manually reset and trip-free units provide positive protection against overloads or short circuits. Service

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to assure
dependable performance

O-M
AIR-HYDRAULIC
CYLINDERS

Complete testing facilities at our modern new assembly plant take the guesswork out of cylinder performance. Before shipment every O-M Air and Hydraulic Cylinder is "power-tested" and approved, assuring dependable prolonged service under all normal operating conditions.

Standard, semi-standard, "special" air and hydraulic cylinders available in full range of sizes (1½" to 8" bores with standard, 2 to 1 or oversize rods. Completely interchangeable parts. Immediate delivery on many sizes.

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One Priceless Element In Every

POPE

PRECISION SPINDLE

THE *Confidence* OF ITS USER

You can have complete confidence in the antifriction bearings POPE puts into your spindles.

They are made to new super-precision tolerances.

You can depend upon Pope Spindles for the continuous production of accurate parts, fast removal of the surplus metal and fine low micro-inch surface finishes.

POPE Spindles have radial and axial rigidity capable of properly supporting modern cutting tools on high production work.

The shafts are large for extra rigidity and have enormous excess capacity.

With the POPE SYSTEM of Grease Lubrication used successfully for thirty-four years, there is no internal radial clearance for oil film in the bearings—none is required. Instead, the bearings are permanently internally preloaded for accurate centering and positioning of the shaft.

POPE leadership in spindle design and constant PROGRESS in engineering and manufacturing reduce your tolerances and production costs.

For trouble-free operation
YOU CAN SPECIFY POPE SPINDLES
WITH *Confidence*

No. 103

Specify POPE
PRECISION SPINDLES

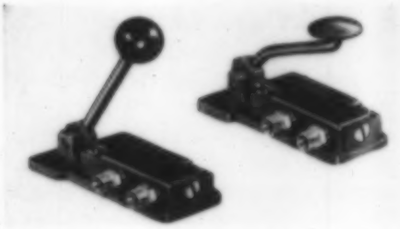
POPE MACHINERY CORPORATION
Established 1920
261 RIVER STREET | HAVERHILL, MASSACHUSETTS

can normally be restored within 10 seconds after harmless overloads or shorts, yet these breakers will not maintain a circuit that has not been cleared. Made by **Mechanical Products Inc.**, 1840 River St., Jackson, Mich.

For more data circle MD-101, Page 215

Pneumatic Valves

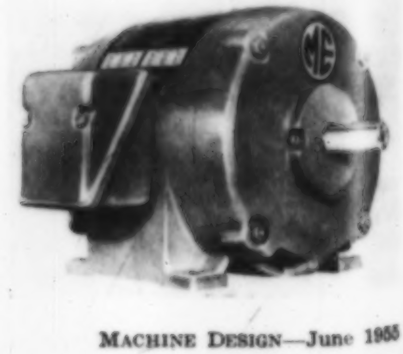
Speedy hand-operated valve No. 75, left, will remain in open or closed position without continual hand pressure. Fingertip valve No. 74, right, is a three-way model which provides fast action for presses, rams or for air cylinders up to a 6-in. bore. Both valves have ¼-in. NPT female ports equipped with ¼-in. male hose fitting connectors. Mounting bosses on base plate facilitate attachment to machine. Available from **W. R. Brown Corp.**, 2701 N. Normandy Ave., Chicago 35, Ill.



For more data circle MD-102, Page 215

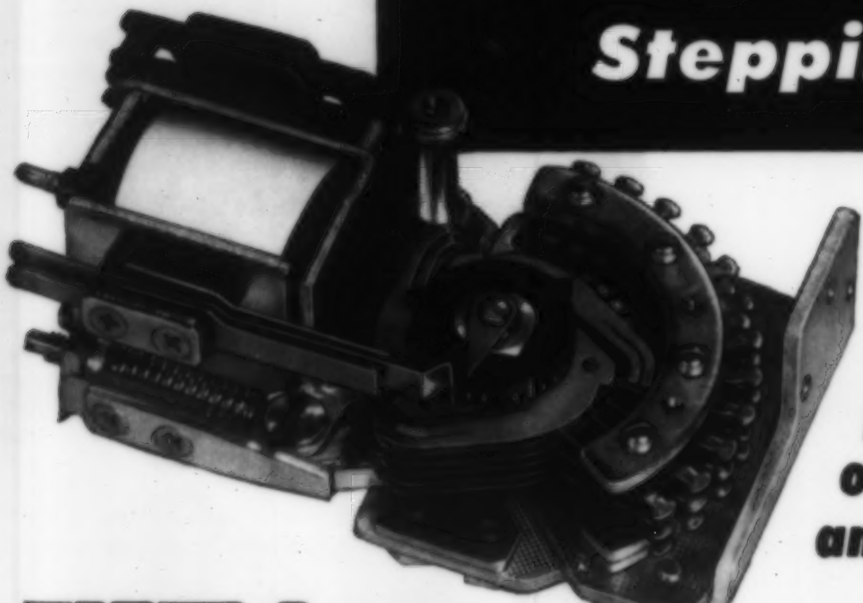
Integral-Horsepower Motor

Protection against splash, drip and weather and guarded construction are provided in this integral horsepower motor. It can be mounted in overhead, side wall or standard floor position. It has cast iron brackets and enclosed frame, screened openings and reinforced and milled feet. Three and single-

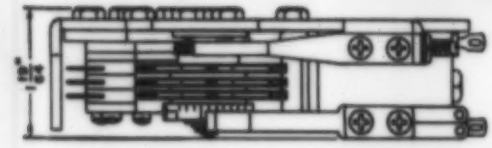


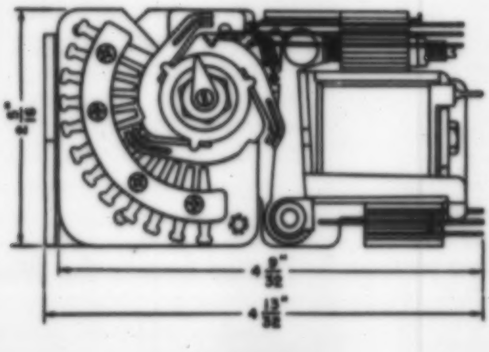
Available NOW!

New CLARE Type 11 Springdriven Stepping Switch



Small, compact design provides millions of steps without any readjustment





This new CLARE Type 11 Springdriven Stepping Switch is the latest in the CLARE line of uniselectors, or rotary switches, for completing, interrupting, or changing the connections in a succession of electric circuits in response to momentary impulses of current.

Like the larger and older switches in the CLARE line—Types 20, 26, 40 and 52—this sturdy, fast-stepping little switch is capable of many different applications, such as:

- ***Selecting any desired point in a series***
- ***Selecting the first unoccupied point in a series***
- ***Sequence controlling: automatically controlling a series of operations in a predetermined manner***
- ***Counting and totalizing***
- ***Generating timed pulses***
- ***Monitoring***

The CLARE Type 11 Switch is designed to be free from critical adjustments. The few adjustment points are unusually easy to reach when required, but choice of materials and design provides millions of steps without any readjustment.

Send for Engineering Bulletin No. 121 for complete information on the new CLARE Type 11. Address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Ill. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable Address: CLARELAY.

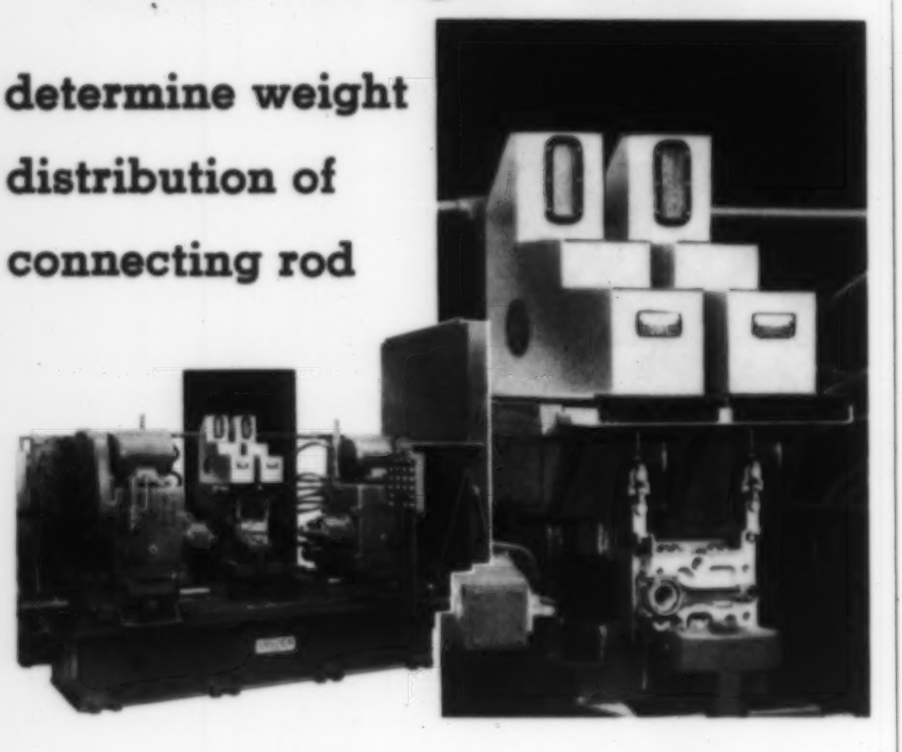
Small size is illustrated by this cutaway view, showing a three-level switch hermetically sealed in a can commonly used to enclose one CLARE Type C Relay

FIRST in the industrial field

CLARE RELAYS

Exact Weight Scales

determine weight distribution of connecting rod



automatically set machine for correct stock removal

PERFECT BALANCE is assured on connecting rods by the use of two EXACT WEIGHT SHADOGRAPH scales built into this Snyder Milling Machine. Closer tolerances are obtained—operation is entirely automatic.

A pair of EXACT WEIGHT scales were specially designed to weigh both ends of workpiece on special hangers attached to scale beams. Scales register amount each end is out of balance and automatically transmit signals that set up units on either side. Balancing is accomplished in one pass milling and conforms to tolerances of 1/16 oz. (1.7 grams) on either end and overall weight. Any rod not meeting maximum machining dimensions is automatically rejected.

Another example how EXACT WEIGHT scales are being utilized in modern machinery design. Complete engineering data is available for designers. Write, giving your specific application.

Sales and Service Coast to Coast

There is no substitute for Exact Weight

Exact Weight Scales

Better quality control

Better cost control

THE EXACT WEIGHT SCALE COMPANY

923 W. Fifth Avenue, Columbus 8, Ohio

In Canada: P. O. Box 179, Station S, Toronto 18, Ont.

phase ratings are available. Vinyl acetal resin on all conductors and Mylar phase separators provide maximum resistance to moisture. Winding is impregnated with silicone treated varnish. Motor is also available in totally enclosed, fan cooled design. Made by **Marathon Electric Mfg. Corp.,** Wausau, Wis.

For more data circle MD-103, Page 215

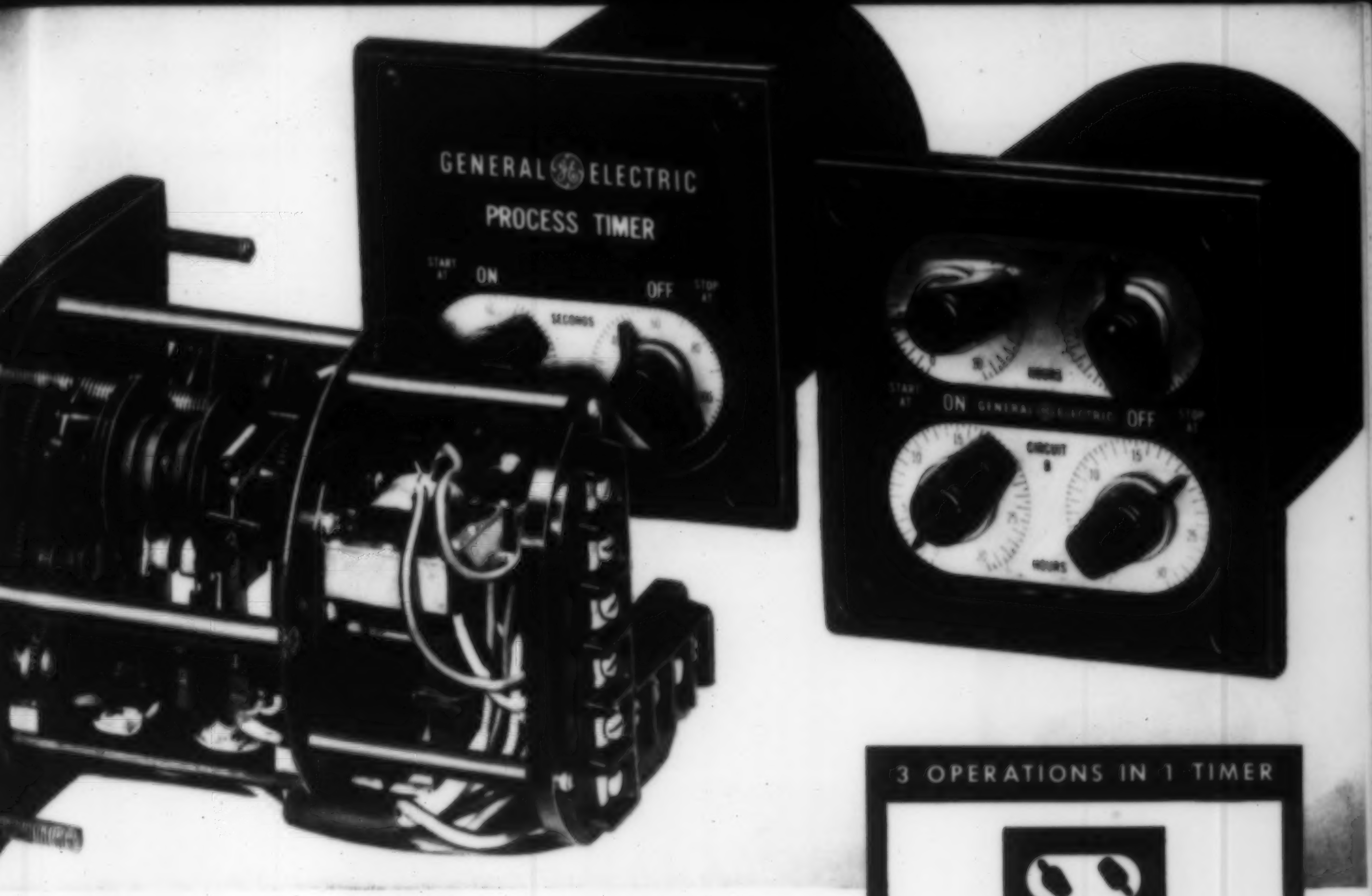
Miniature Relay

Simple type 11F single-pole, double-throw relay is used in such devices as automatic headlight dimmers, radiosondes and radio controlled toys. Tentative specifications are: operation on 50 mw (24 ma in 9000-ohm coil); 1 amp maximum contact load; up to 9000-ohm coil resistance; and weight of 1 oz. Relay measures 1 5/32 x 1 5/16 x 1 in. Made by **Sigma Instruments Inc.,** 81 Pearl St., South Braintree, Boston 85, Mass.

For more data circle MD-104, Page 215

Thread Inserts for Wood

Readily inserted in drilled hole in wood surfaces, Knife-Thread inserts provide durable steel tapped thread in which bolts or screws can be used. Fasteners can be assembled and disassembled many times without damage to threads or loss of



NEW G-E TIMER

Cuts Process Timing-equipment Costs

he new General Electric TSA-18 rocess timer, available in single- nd double-circuit models, reduces our need for expensive, custom- uilt timing equipment. Its adapt- bility enables it to meet, with recise and dependable operation, he majority of your timing-equip- ment requirements.

HREE TYPES OF CONTROL are vailable in the TSA-18. At no xtra cost this new process timer is apable of being connected for manual start and reset, automatic eset, and automatic reset and re- peat operations.

DJUSTABLE "ON"-"OFF" TIME etting is provided in this new imer. The TSA-18 will begin and nd a process at any specified time. Load circuits can be easily adjusted to close or open at any point within this cycle. This feature enables you to reduce the multiple number of timers usually required to perform these timing operations.

HEAVY-DUTY CONSTRUCTION of the TSA-18 reduces maintenance and repair costs and provides long life. Nylon gears, permanently lubricated Telechron* motor, hardened steel parts, and 1/16-inch solid silver-face contacts contribute to the new timer's long life.

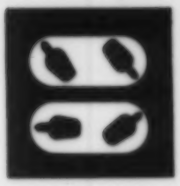
FOR MORE INFORMATION call your nearest General Electric Apparatus Sales Office, or write for Bulletin GEC-1223 to Section 603-179, General Electric Co., Schenectady 5, New York.

*Registered trade-mark, General Electric Co.

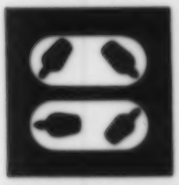
Progress Is Our Most Important Product

GENERAL ELECTRIC

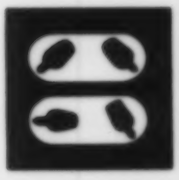
3 OPERATIONS IN 1 TIMER



MANUAL OPERATION
Timer is started and reset manually from an external switch. Two adjustable load circuits independent of each other are available with this type of operation.



SEMI-AUTOMATIC OPERATION
Timer is started from external switch. Circuit "A" resets time at the end of the adjustable cycle. Circuit "B" opens and closes load circuit within the cycle.



AUTOMATIC OPERATION
Circuit "A" starts and repeats the cycle for continuous operation. Circuit "B" opens and closes load circuit at any point within the cycle.

ACTUAL SIZE

7/8"

never before...
a potentiometer
the size of a penny
yet worth a fortune
in performance!

DeJUR Series C-078

SUBMINIATURE POTENTIOMETERS

Now – the features of full-size potentiometers in a new series that's no larger than a penny! If your product is for computers, trimmers, guided missiles, or any portable or aircraft equipment, DeJUR's new subminiature potentiometers help you achieve substantial savings in weight and space.

- **Unit height only ⅞", weight only ½ oz.**
- **Single or multiple gangs**
- **Independently phased**
- **Completely enclosed**
- **320° electrical and 326° mechanical rotation**
- **Gold collector for trouble-free contacts**
- **Multiple-finger precious metal contact brush**
- **Available with special torque ratings, ball-bearings, sealed housings, special tolerances and other requirements for any linear or non-linear function.**

WRITE FOR COMPLETE TECHNICAL LITERATURE. *No obligation. Our engineering department can supply prototypes to meet unusual design specifications for tests and approval. Send us your specs for analysis.*

DeJUR-AMSCO CORPORATION • 45-01 NORTHERN BLVD.
LONG ISLAND CITY 1, N. Y.

- potentiometers
- connectors
- instruments

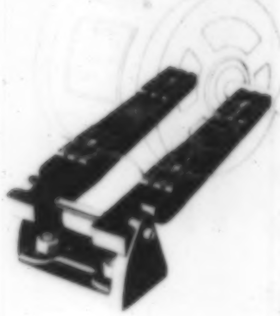
you're sure with **DeJUR** electronic sales division

holding power. Inserts have blade-sharp external thread which cuts its way into the wood without crushing the fibers. Hold is extremely tenacious. Inserts are cadmium plated to resist corrosion. They are available in a variety of sizes with both fine or coarse machine threads. Made by **Rosan Inc.**, 2901 W. Coast Highway, Newport Beach, Calif.

For more data circle MD-105, Page 215

Pivoted Motor Base

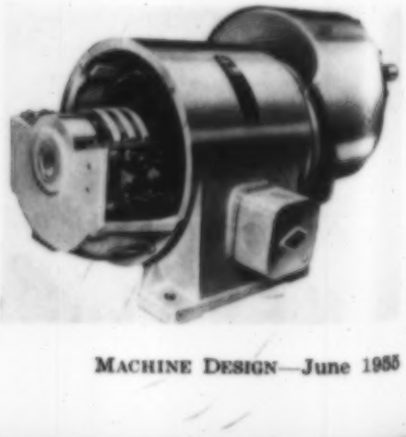
Line of four Auto-Tension motor bases can be used with flat or V-belt drives for motors from 1/6 to 7½ hp. Bases maintain proper belt tension for all load conditions and compensate for belt stretch. Belts can be changed without disturbing the motor mounting. Made by **Rockwood Pulley Mfg. Co.**, 20 Crosby St., New York 13, N. Y.



For more data circle MD-106, Page 215

Motorized Speed Reducer

Variable speed reduction and high starting torque on low starting current are features of this slip ring Motoreducer. The speed reducer can be mounted on the motor at any one of four positions.



DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS

Founder Celebrates 25 Years' Service To Silicone Industry

In 1930, Dr. J. F. Hyde first started his investigations into the field of organosilicon chemistry. His work, which preceded that of any other chemist in this country, led to the first commercial production of silicones.

Frank Hyde received a master's degree in chemistry from Syracuse University in 1924. He then enrolled in the graduate school of the University of Illinois and received his Ph.D. in organic chemistry in 1928. To pursue still further his interest in basic organic chemistry, he spent two years as a post Doctorate Fellow at Harvard University under Dr. J. B. Conant.

Dr. J. F. Hyde

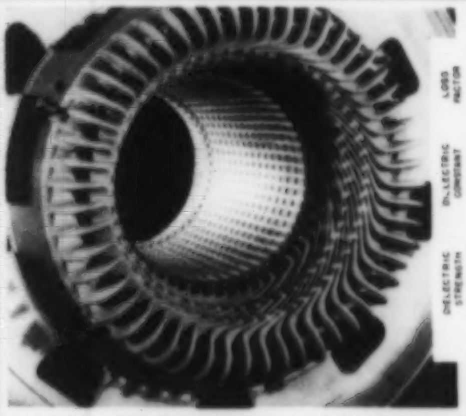
Hyde's work in the field of silicone chemistry began the day he was hired by Dr. E. C. Sullivan of Corning Glass Works in 1930. His first project was to explore the possibility of incorporating organic chemical groups into glass compositions to increase their shock resistance and flexibility. His investigations led deep into the work done by Prof. F. S. Kipping of Nottingham University (England) in the field of organosilicon chemistry. Applying his creative imagination to Kipping's findings, Hyde produced silicone polymers with the very properties that so rapidly propelled the silicones into almost every phase of American industry.

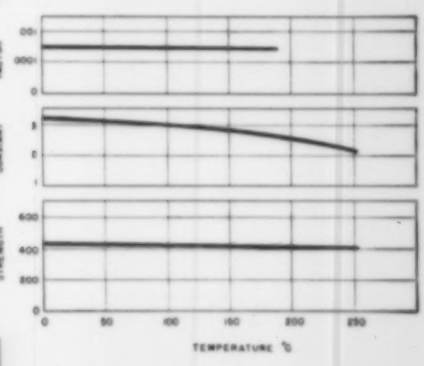
Frank Hyde carried on basic exploratory work in the silicone field at Corning until 1951. He then transferred his laboratory to Midland, Michigan, to be closer to actual silicone operations at Dow Corning Corporation where he continues to apply his research ability to producing more and better silicone products.

At this time, many people join us in saying,

CONGRATULATIONS TO THE MAN WHO WAS FIRST IN THE WORLD TO PRODUCE A USEFUL SILICONE AND ON WHOSE WORK AN INDUSTRY WAS FOUNDED

DR E C SULLIVAN





ALLIS-CHALMERS ANNOUNCES ALL-SILICONE-RUBBER INSULATION FOR LARGE MOTORS AND GENERATORS

Allis-Chalmers Manufacturing Co. has announced development of the first all-silicone-rubber electrical insulating system for large motors and generators. Known as Silco-Flex, this new Class H insulation increases the life and efficiency of rotating electric machines by providing greater overload protection and maximum resistance to abrasion, moisture, shock, and vibration.

Made with Silastic*, the Dow Corning silicone rubber, Silco-Flex is dielectrically superior to all types of resinous insulations. As shown in the figure, dielectric strength of 1/16 inch slabs cured 24 hours at 250 C remains practically constant over a temperature span ranging from 0 to 250 C. Dielectric constant decreases gradually from 3.2 to zero to 2.2 at 250 C.

In manufacturing Silco-Flex insulated stator coils, Silastic is applied to the conductors and vulcanized into a homogeneous mass by the application of heat and pressure. This produces a continuous and impervious dielectric barrier which provides a flexible, moisture and heat resistant wall over the entire coil structure including leads.

Silco-Flex insulation is expected to change many of the motor application practices in the utility and industrial fields. In power plant induced draft fan motors, for example, the abrasive effect of atmosphere-borne cinder and fly ash will have little effect on the resilient all-silicone-rubber system. Motors in cement, ore crushing and similar installations will retain high overload capacities despite reduced ventilation resulting from dust accumulation in ventilating passages. In the chemical, paper, food and similar industries, applications that formerly required totally enclosed motor frames may now be supplied more efficiently and economically with Silco-Flex insulated semi-protected or open type frames.

Allis-Chalmers is already building large Silco-Flex insulated machines in the 2300 and 4000 volt class. These will be priced on the same basis as pervious units constructed with resinous Class H insulation. A-C engineers also expect to extend the advantages of the all-silicone-rubber system to a wide range of high and low voltage rotating equipment. ***No. 41***

*T.M. REG. U.S. PAT. OFF.

Design Edition 10

DOW CORNING CORPORATION - Dept. 6806
Midland, Michigan

Please send me more data on number: 41

NAME ____________________

TITLE ____________________

COMPANY ____________________

STREET ____________________

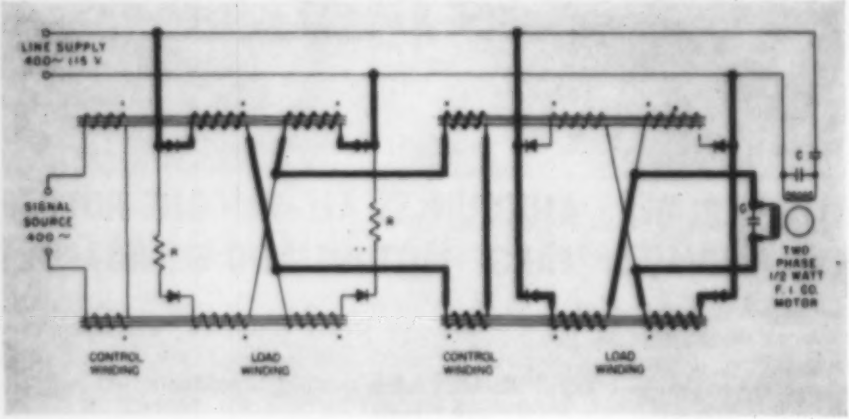
CITY __________ ZONE ______ STATE ______

ATLANTA • CHICAGO • CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEW YORK • WASHINGTON, D. C. (Silver Spring, Md.)
Canada: Dow Corning Silicones Ltd., Toronto; **Great Britain:** Midland Silicones Ltd., London; **France:** St. Gobain, Paris

SINCE 1915 LEADERS IN AUTOMATIC CONTROL

HALF-WAVE FAST RESPONSE MAGNETIC AMPLIFIER CIRCUITS

An important requisite of any practical amplifier is that it should be possible to cascade several units if more amplification is required than a single stage can offer. In usual magnetic amplifiers, this creates some practical difficulties because the inherently long time constants of each stage add up, and the cumulative time constant of the several stages may become excessive for practical applications.



Ford Instrument Company has perfected and holds the basic patents on circuits which allow cascading magnetic amplifiers with stages operating on successive half-cycles of the a-c supply.

In the circuit shown here, amplification in each stage of the amplifier is accomplished by pre-setting the core fluxes with the control-winding signal during one half-cycle of the applied load-winding voltage. During the next half-cycle, when the load-winding conducts, the control winding contribution is negligible. In this mode of operation the control winding of each stage of the amplifier receives its signal during the reset or non-conducting half-cycle of that stage of amplification. The effect of this signal occurs during the next half-cycle, thus the time constant in the stage is at a minimum of ½ cycle.

The amplifier uses half as many elements (cores and rectifiers) as the conventional bridge (full-wave circuit), and has a constantly higher figure of merit (power gain per cycle of time constant).

In amplification problems it will pay you to talk to the engineers of Ford Instrument Company. For forty years this company has specialized in designing and manufacturing special computers and controls. Send your problem to Ford.

57

FORD INSTRUMENT COMPANY
DIVISION OF THE SPERRY CORPORATION
31-10 Thomson Avenue, Long Island City 1, N.Y.

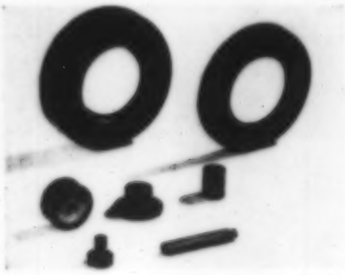
ENGINEERS
of unusual abilities can find a future at FORD INSTRUMENT COMPANY. Write for information.

90-deg apart, to afford space savings when used in close quarters. Motors are available in ratings of ½ to 5 hp with output speeds of 520 to 16 rpm. Drive motor can be dripproof or totally enclosed. Made by **Reuland Electric Co.,** 3001 W. Mission Rd., Alhambra, Calif.

For more data circle MD-107, Page 215

Molding Material

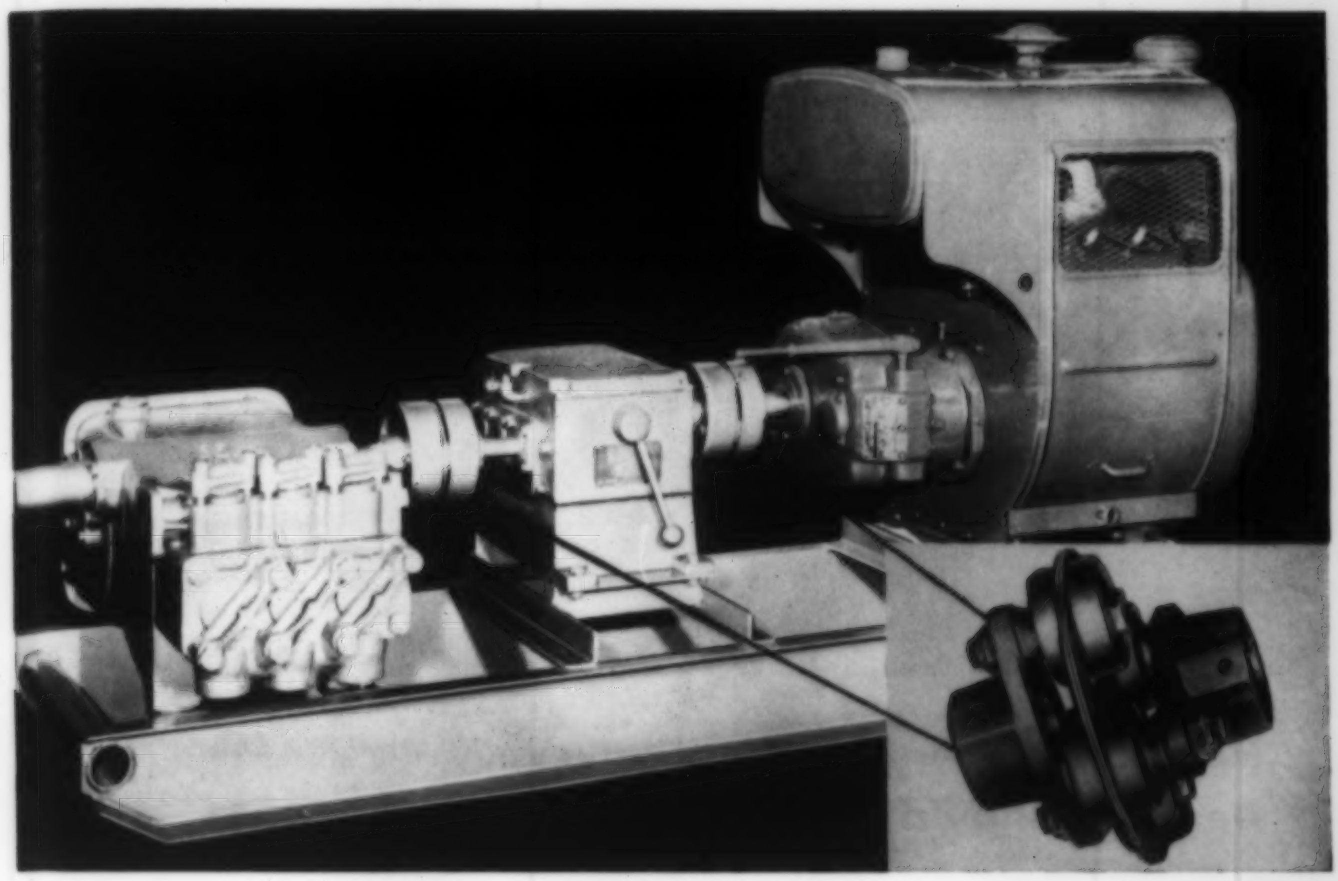
Electronic parts molded of flurothene can be used in temperature range from −320 to 390 F. Suitable for insulators and other parts for high frequency radio circuits, as shown in illustration, the material has low dielectric constant and high dielectric strength. Parts are injection molded to close tolerances with few weld lines or sink marks. Flurothene can also be extruded, coated or cast. It is unaffected by dry ice, dust, salt spray or fungus and is resistant to attack by fuels and chemicals such as fuming nitric acid. Made by Bakelite Co. Div., **Union Carbide and Carbon Corp.,** 260 Madison Ave., New York 16, N. Y.



For more data circle MD-108, Page 215

Miniature Potentiometer

Precision commutator and impulse generator is designed for use as a high-speed switching device for such operations as counting, digital indication of shaft rotation, pulse shaping, pulse gating, and sequence circuit control. The device consists of a series of conducting segments, bonded to a high-temperature plastic base, insulated from one another, and interconnected to form a wide variety of coded commutation or pulse se-



John Bean Core Drill Pumping Unit, Model 435CD, is a highly versatile machine used to flush diamond core drill cuttings from drill holes. In shaley structures, it can immediately be converted from mud to cement pumping. Its unique 3-speed transmission enables it to vary discharge capacity from 11 to 35 GPM, at pressures from 300 to 700 PSI.

The compact coupling arrangement enables the complete pump assembly to be mounted on one skid, greatly facilitating erection, disassembly, and transportation.

Morse Morflex Couplings (shown at right without safety covers) are ideally suited for a job such as this. They are flexible; are capable of transmitting power smoothly, absorbing variant shock loads, and compensating for severe torsional and dimensional misalignment.

Morse Morflex Couplings prove their dependability in new pumping unit

Morse Morflex Couplings were specifically designed to meet machine requirements such as those of the John Bean Core Drill Pumping Unit.

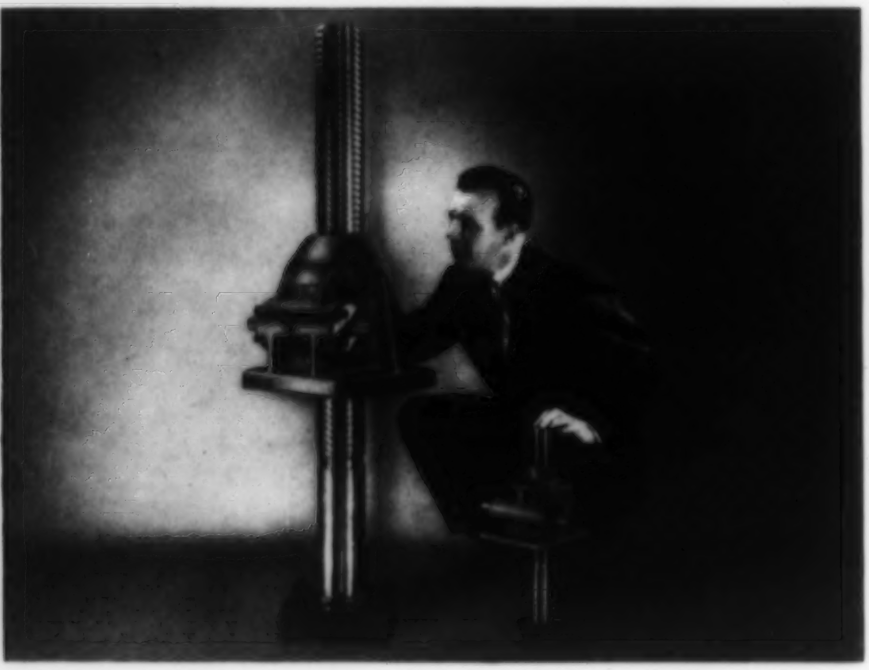
Morse Morflex Couplings do not require lubrication and maintenance, because there are no moving parts to wear. They accommodate all conditions of misalignment and torsional load vibration by elastic deflection of neoprene biscuits. They are impervious to water, dirt, oil, and weather conditions; they are compact, and dependable.

Morse Morflex Couplings offer smooth, vibration-free power transmission without undue thrust loads on the drive shaft bearings. Shock loads are cushioned, bearing life prolonged, and quiet operation is assured. And most important—downtime is reduced to a minimum!

Investigate the many advantages of using Morse Morflex Couplings, as well as other Morse precision-built power transmission products, on your equipment: Morse Roller Chain, Sprockets, Roller and Silent Chain, Couplings, Cable Chain, and Clutches. MORSE CHAIN COMPANY, INDUSTRIAL SALES DIVISION, ITHACA, NEW YORK.

MORSE BW

CHAINS, CLUTCHES, AND COUPLINGS



Here's A Device Every Machinery Designer Should Know About . . .

It's the Duff-Norton Worm Gear Jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion, applying pressure, resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes or any power-operated positive control system so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 35 tons with any raise up to 25 inches; worm gear ratios, 8:1 to 96:1; turn of worm for each 1-inch raise, 10 to 180; available in either Acme or square threads. Screw ends and tops are available in many types and can be readily adapted to your specific requirements.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting—raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses—adjusting electrodes—overhead crane servicing.

Duff-Norton Worm Gear Jacks are available in 6 standard sizes or to your special order. For complete specifications and detailed drawings, send for your free copy of a special brochure.

DUFF-NORTON Company

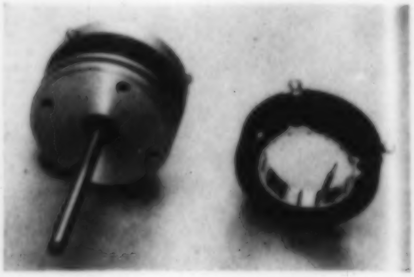
DUFF-NORTON COMPANY
Department MD
P.O. Box 1889, Pittsburgh 30, Pa.

Please send immediately a free copy of your new Worm Gear Jack Brochure.

NAME TITLE

COMPANY PHONE

ADDRESS

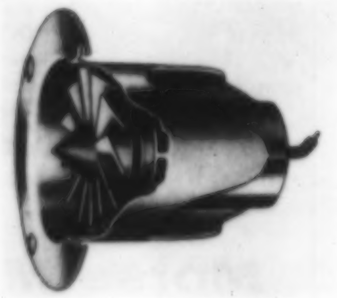


quences. Multiple isolated wipers permit commutation in several circuits simultaneously. The potentiometer is approximately 1 in. in diameter and weighs 0.2-oz. Operating speed limit is 1000 rpm. Made by **Computer Instruments Corp.**, 1964 Utica Ave., Brooklyn 34, N. Y.

For more data circle MD-109, Page 215

Axial Flow Blower

Compact blower is powered by either a dc or a 400-cycle ac miniature motor. Body of the blower is 2 in. in diameter by 3 in. long. Output is 60 cfm of free air at less than 1 amp. Incorporation of a nose spinner in the impeller design provides large amount of effective blade area, resulting in low noise and high air flow. Blowers can be supplied with radio noise filters. Made by **Air Equipment Co.**, 2248 E. 37th St., Los Angeles, Calif.



For more data circle MD-110, Page 215

Aluminum Inserts

Standardized aluminum inserts for use in molded plastics have holes which are tapped to maximum depth for overall length. Inserts have Class II threads to meet ASME specifications and are available in sizes from 4-36 to 12-24. Holes are reamed after tapping to

ELF-CLEANING . . . ABRASION RESISTANT

. . . for Extra tough service

Revolutionary Tobacco Harvesters

Rely on ATLAS CHAIN to keep going in mud and sand

Tough abrasive action of sand, dirt and mud is the type of punishment Atlas Chain and Sprockets must take on this "Silent Flame" Tobacco Harvester manufactured by the Long Manufacturing Company. The chain and sprockets are bombarded by an endless stream of dirt kicked up by the wheels and at times actually operates with the chain churning a path out of the mud and sand.

This is the type of service that has proved the extra wear built into every link of Atlas Chain. Plates, pins and bushings are super-toughened by Atlas' exclusive heat treating process assuring stronger operating chain over longer periods. Rollers, pins and bushings are "Micro-Finished" to exact tolerances for smooth, quiet operation.

Whether a standard pitch chain as used on the drive . . . a special extended pitch as on the leaf conveyor . . . or the sprockets throughout the harvester, Atlas makes a complete line of precision matched chain and sprockets to meet every requirement. Write for your copy of the new handbook on chain and sprockets ARC-55.

ATLAS CHAIN & MANUFACTURING COMPANY · DOYLESTOWN, PENNA.

ATLAS ROLLER CHAIN AND SPROCKETS

Remember!

When you specify Mechanical Seals...

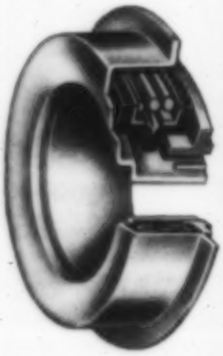
JOHN CRANE

can supply the
exact seal
you require

You can achieve the sealing efficiency you want . . . eliminate specification problems . . . work unhampered from drawing board to production—when you work hand-in-hand with "John Crane's" experienced engineering staff and available facilities.

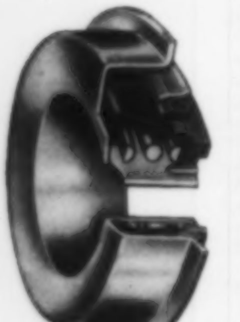
Get quick, finger tip information on "John Crane's" complete line of high production mechanical seals—for every conceivable service—to meet your particular needs. Send now for illustrated technical catalog. It's your's upon request.

JOHN CRANE
Mechanical Seals



TYPE 6-A

Pressed-in packaged unit recommended for small shafts on hot or cold water, oil, gasoline or soapy liquids . . . pressures to 75 psi . . . temperatures from —65° F. to +220° F. Available in stainless steel or bronze.



TYPE 11-A

Pressed-in packaged unit with spring inside synthetic rubber bellows to protect against corrosion. For hot or cold water, oil, gasoline or soapy liquids . . . pressures to 35 psi . . . temperatures from —65° F. to +212° F.

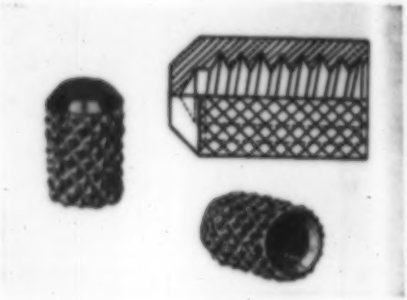
TYPE 19

An all-purpose seal suitable for handling practically any liquid or gas, including highly corrosive acids and oils. Low or high temperatures from —100° F. to + 450° F. . . . pressures to 200 psi. Incorporates highly efficient sealing cones made of Du Pont's Teflon, which is inert to practically all chemicals.

Crane Packing Company, 1825 Cuyler Ave., Chicago 13, Illinois
In Canada: Crane Packing Co., Ltd., 617 Parkdale Ave., N., Hamilton, Ont.

JOHN CRANE

CRANE PACKING COMPANY



maintain exact tolerances and to facilitate securing of the inserts on the locating pins. Extremely coarse outside knurl provides good holding power against high torque. Made by **Yardley Precision Products Co.**, 30 E. Afton Ave., Yardley, Pa.

For more data circle MD-111, Page 215

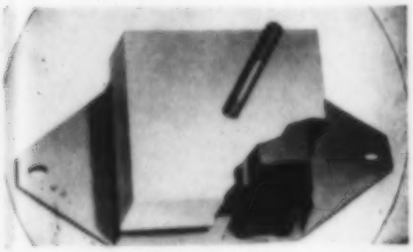
Fractional-Horsepower Motors

Absence of an internal relay, which would delay reversing action, makes this line of fractional horsepower motors instantly reversible. A compact high-voltage capacitor helps start and reverse heavy loads. Motors are designed for use on door operators, machine tools, cranes and hoists and are offered in ¼, ⅓, ½ and ¾-hp ratings. They operate on either 115 or 230-v 60-cycle ac at 1725 rpm. Made by **General Electric Co.**, Schenectady 5, N. Y.

For more data circle MD-112, Page 215

Vibration Mount

Rexon vibration mount consists of one or more X-shaped rubber elements encased in steel channels. Under normal loading, points of the X deflect enough to provide "floating" suspension. If overloaded, X-shaped elements merely become



conventional compression mounts. Direction of vibration and weight each mount will bear are only ordering information needed. Mounts are offered in sizes to support from ½ to 3800 lb. Neoprene element resists oils, grease, moisture and cleaning solvents. Made by **Hamilton Kent Mfg. Co.,** 218 Gougler St., Kent, O.

For more data circle MD-113, Page 215

Solenoid Air Valve

Hi-Cyclic line of solenoid valve-piloted air valves now includes ½, ¾ and 1-in. NPT sizes. Compact valves are capable of high actuation rates and operate on short electrical signals. The single solenoid valve measures less than 11 x 5½ x 4 in. high in the 1-in. port size; the double solenoid valve, illustrated, is less than 14 in. long overall. These three-way and four-way valves are available for operation at 1.4 to 475 v dc and 3.6 to 750 v ac at 25, 30, 40, 50 and 60 cycles. Made by **Beckett-Harcum Co.,** Wayne Rd., Wilmington, O.

For more data circle MD-114, Page 215

Hollow Lock Screws

Designed to act as internal lock nuts for set-screws subjected to high speeds and vibration, Mac-it hollow lock screws hold securely. They are heat treated alloy steel with hex socket cut all the way

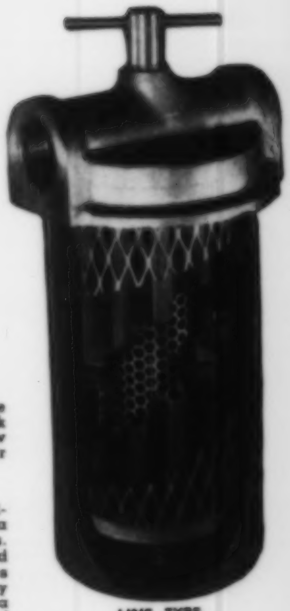
(*Continued on Page* 268)

For Dependable Protection On Hydraulic Equipment

MARVEL SYNCLINAL FILTERS

SUMP TYPE
(cutaway)

Over 550 Original Equipment Manufacturers Install Marvel Synclinal Filters as Standard Equipment.



LINE TYPE
(cutaway)

Hydraulic Oils MUST BE CLEAN to Protect Equipment— Increase Production— Reduce Maintenance

PRODUCTION ENGINEERS and MAINTENANCE MEN, whose job it is to keep production machinery operating at peak efficiency, are specifying Marvel Synclinal Filters on new equipment and standardizing with Marvels throughout their plants.

It's The ACTIVE Filtering Area That Counts!

The Synclinal design of Marvel Filters provides that all-important balance between maximum ACTIVE filtering area and sufficient storage capacity for filtered out particles. Thus, longer periods of productive operation are attained before filter cleaning is necessary. Marvel Synclinal Filters are easy to clean because both the sump and line type may be disassembled, thoroughly cleaned and reassembled in a matter of minutes. Line type operates in any position and may be serviced without disturbing pipe connections.

A SIZE FOR EVERY NEED

Available for sump or line installation in capacities from 5 to 100 G.P.M. Greater capacities may be attained by multiple installation (as described in catalog). Choice of monel mesh sizes range from coarse 30 to fine 200.

IMMEDIATE DELIVERY!

As in the past, Marvel continues to offer IMMEDIATE DELIVERY.

FILTERS FOR FIRE-RESISTANT HYDRAULIC FLUIDS

Marvel's most recent development is a filter for the efficient filtration of all types of fire-resistant hydraulic fluids.

WATER FILTERS

Both sump and line type filters have been adapted for use in all water filtering applications. No changes have been made in the basic, balanced synclinal design.

MARVEL ENGINEERING COMPANY
625 W. Jackson Blvd., Chicago 6, Ill.
Phones — Franklin 2-3530 and Franklin 2-4431

Catalogs containing complete data available on request

Without obligation, please send me complete data on Marvel Synclinal Filters, as indicated:
☐ Catalog #106—For Hydraulic Oils, Coolants and Lubricants
☐ Catalog #300—For WATER
☐ Data on filters for Fire-resistant hydraulic fluids.
Name ....
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Company ....
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MD-6

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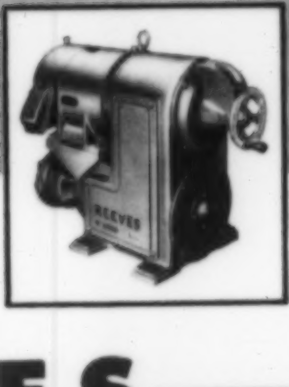

REEVES PULLEY COMPANY
COLUMBUS, INDIANA
DIVISION OF
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Factory pre-setting assures high accuracy . . . eliminates costly pre-installation adjustments

Cramer CYCLING TIMERS

The accuracy of a cycling timer depends on the exactness of the cam settings. If any one of the driving cams is incorrectly set, even to the minutest degree, the over-all program pattern or sequence of operations is changed.

Cramer cycling timers are normally supplied with all cams pre-set to customer specifications on special calibration equipment like that shown above. This pantographic principle, in effect, produces a sixteen-time enlargement of the cam, permitting extremely close setting accuracies.

While these timers can be adjusted in the field, factory setting assures highest accuracy and eliminates costly pre-installation adjustments.

This is but one of the many Cramer customer services designed to provide greater product usefulness and satisfaction at lower cost.

For full information about Cramer Cycling Timers, write for new Bulletin PB-510.

Cramer TIMING DEVICES

SPECIALISTS IN TIME CONTROL

The R. W. CRAMER CO., Inc.

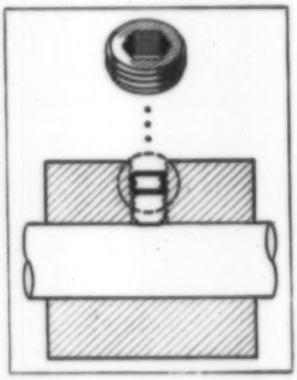
BOX 6, CENTERBROOK, CONNECTICUT

13CR55

New Parts

(*Continued from Page 265*)

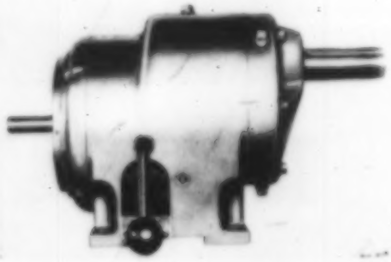
through to permit adjustment or resetting the setscrew without removal of the lock screw. When set firmly in place, the lock screw presses against the upper surface of the set screw, as illustrated. Lock screws are produced with fine or coarse threads in 12 standard diameters from No. 6 to 1 in. and in lengths according to diameter. Available from **Strong, Carlisle & Hammond Co.,** Mac-it Div., 1394 W. Third St., Cleveland 13, O.



For more data circle MD-115, Page 215

Gearshift Drive

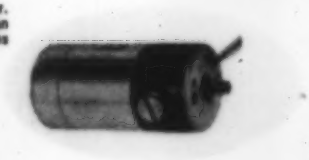
Type R3DC gearshift drive has a capacity of 5 hp at 1800 rpm. It provides four constant horsepower output speeds when used with a single-speed motor; eight output speeds are developed when the drive is used with a two-speed motor. Primary gear ratios are 4.15:1, 3.15:1, 1.85:1 and 1:1. Eleven optional secondary gear ratios are available, ranging to a maximum of 2.25:1. Speed range, which depends on the speed of the motor used with the drive, is from 93 to 1730 rpm at full load. Drive is suitable for all types of machinery and processing equipment requiring a lower than normal



Torq-Master, used with torque converters and fluid couplings in the lumber industry

Giant gear and rack

Right angle vertical pump drive


Miniature motor. One of more than 50 basic designs

Pacific, G-E gearmotor

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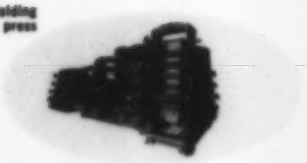
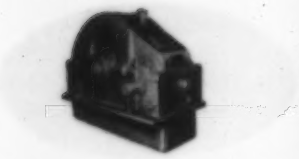
- complete line of electro-mechanical catalog products
- gears of all types and sizes

Illustrated are only a few of the wide variety of both custom and standard products designed and manufactured by Western Gear.


Manifolding press

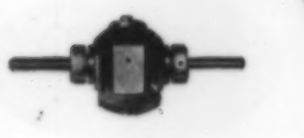
Right angle speed reducer


High speed unit

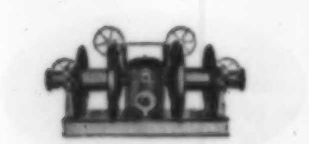
Centrifugal blower, one of many design sizes

Helicopter rotor drive unit

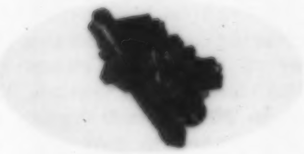
Sea-Master marine gear


Miniature precision differential unit

Aircraft cable drum type hoist, hydraulic, pneumatic or electric drive


Trawl winch

Rotary actuator powered by both hydraulic and electric motors. One of hundreds of basic designs


Horizontal stabilizer actuator unit. AC and DC power providing three speeds for manual, auto pilot and coarse control

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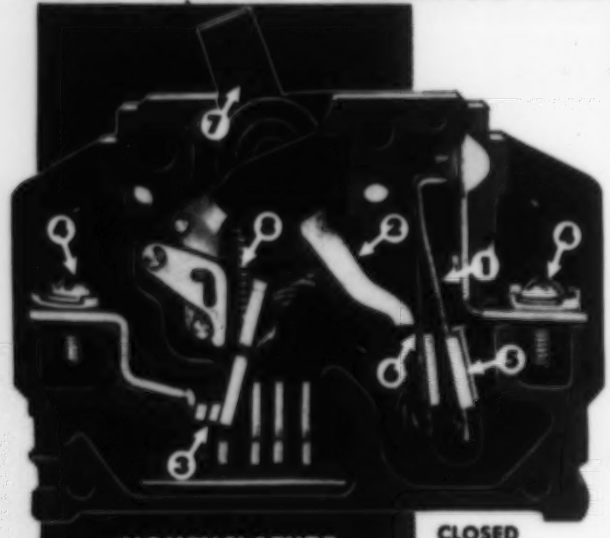
HOW CHACE THERMOSTATIC BIMETAL ACTUATES THE I-T-E CIRCUIT BREAKER

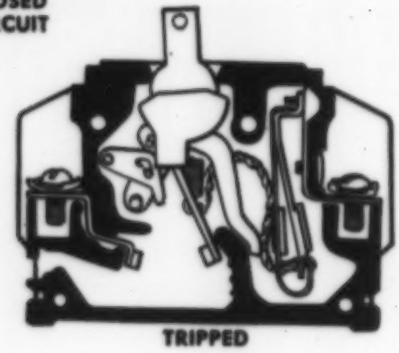
PRODUCT OF
I-T-E CIRCUIT BREAKER CO.,
PHILADELPHIA, PENNSYLVANIA



CLOSED CIRCUIT

NOMENCLATURE

1 BIMETALLIC ELEMENT
2 LATCHING ARM
3 CONTACTS
4 TERMINAL
5 INSTANTANEOUS MAGNETIC TRIP
6 LATCH TRIP
7 MANUAL OPERATING HANDLE
8 SPRING



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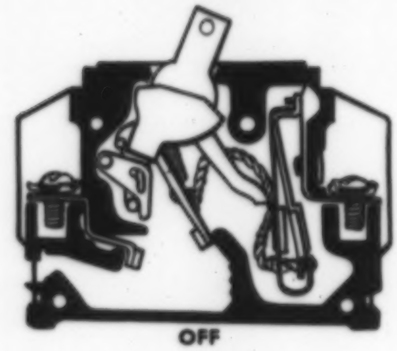


OFF

I-T-E type EQ breakers are designed for use in panelboards and load centers or for individual mounting where the voltage does not exceed 120 volts a-c to ground. It combines thermal-magnetic tripping action to afford complete protection against both small overloads and short circuit faults. Arc chutes, silver alloy contacts and a quick make-and-break trip-free mechanism combine to make this a premium grade breaker. It is furnished in either one or two pole designs.

HOW IT OPERATES

An element of Chace Thermostatic Bimetal furnishes the actuating medium for breaking the circuit under conditions of small, gradual overload. The bimetal strip (1) is carefully and accurately calibrated to deflect at a predetermined temperature range. Its deflection directly actuates the tripping mechanism of the circuit breaker by releasing the spring-loaded latching arm at (2) causing the contact rocker to break the circuit instantly at contacts (3) in response to the same spring tension. **Chace Thermostatic Bimetal is available in 29 different types, in strip, coils or in complete elements fabricated to customer specifications. Send for our new, free 36-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing valuable engineering information for designers of thermally responsive devices.**

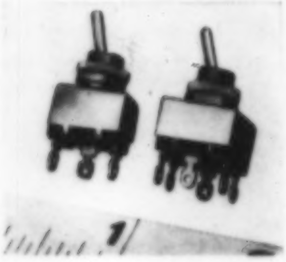
W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE. DETROIT 9, MICH.

range of positive selective speeds. Made by **Lima Electric Motor Co.**, 117 Findlay Rd., Lima, O.

For more data circle MD-116, Page 215

Miniature Toggle Switch

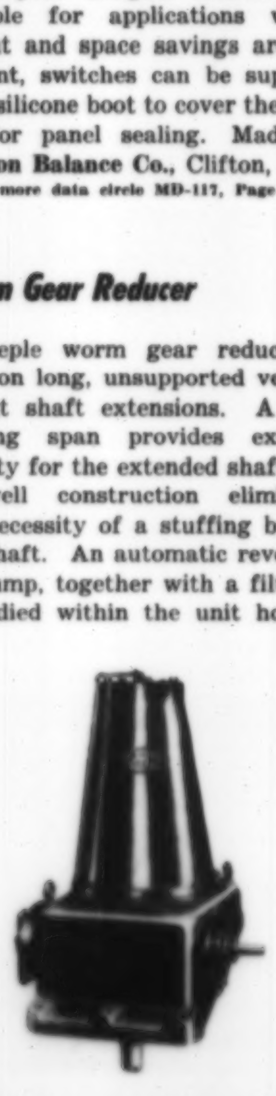
Reduced by half in size and weight from former units with similar capacity, Tor-Bal subminiature toggle switches have contact ratings of 10 amp on 50 v dc. They are double-throw type in single and double-pole designs. Particularly suitable for applications where weight and space savings are important, switches can be supplied with silicone boot to cover the handle for panel sealing. Made by **Torsion Balance Co.**, Clifton, N. J.



For more data circle MD-117, Page 215

Worm Gear Reducer

Steeple worm gear reducer is used on long, unsupported vertical output shaft extensions. A wide bearing span provides extreme rigidity for the extended shaft, and dry-well construction eliminates the necessity of a stuffing box on the shaft. An automatic reversing oil pump, together with a filter, is embodied within the unit housing



STANDS W AR.... AR...HEAT

PENFLEX TUBING
HAS TRIPLE LIFE WHERE OTHERS FAILED

Heat . . . pressure . . . constant flexing were the operating conditions on the "watch-case moulds" in a large tire plant. Many other metallic hoses had been used. Pre-mature failures resulted in a call to Penflex.

"Flexineering" went to work. The situation studied. The proper type of Penflexweld wire braided hose installed. Now, these Penflex products have built up a consistent record of lasting three to four times longer than the previous products used.

When specifying corrugated tubing or flexible metallic hose be certain you decide on the best. Let Penflex engineers show you how "Flexineering" can save you time, maintenance, production and money. They are ready to supply you with a complete line of four wall interlocked and seamless welded corrugated flexible tubing in sizes from 1/8" to 30" I.D. Write today for the new fact book on flexible tubing.

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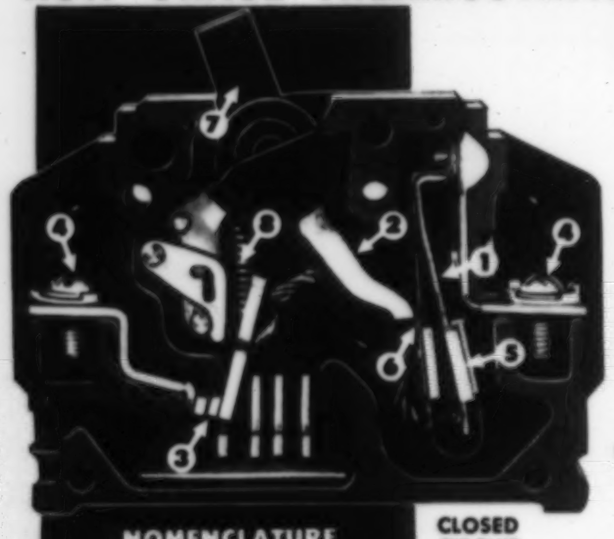
ENFLEX

HEART OF INDUSTRY'S LIFE LINES

HOW CHACE THERMOSTATIC BIMETAL ACTUATES THE I-T-E CIRCUIT BREAKER

PRODUCT OF
I-T-E CIRCUIT BREAKER CO.,
PHILADELPHIA, PENNSYLVANIA



NOMENCLATURE
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2 LATCHING ARM
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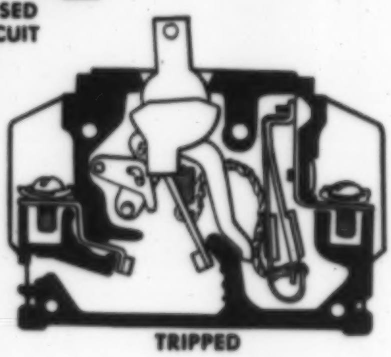
CLOSED CIRCUIT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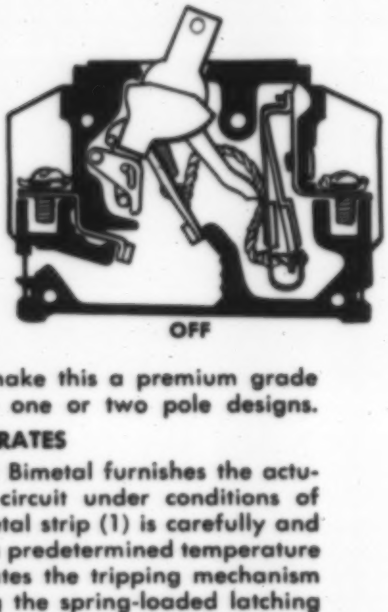
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IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

range of positive selective speeds. Made by **Lima Electric Motor Co.,** 117 Findlay Rd., Lima, O.

For more data circle MD-116, Page 215

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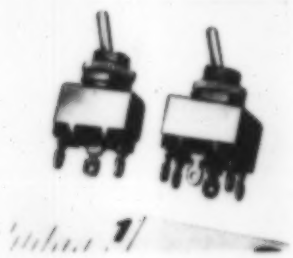

For more data circle MD-117, Page 215

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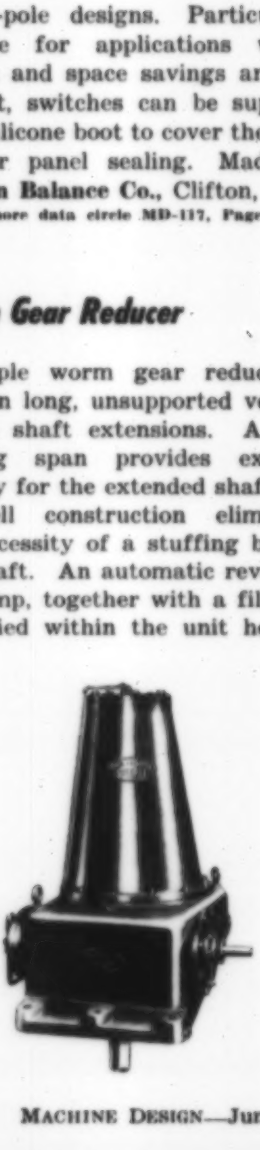
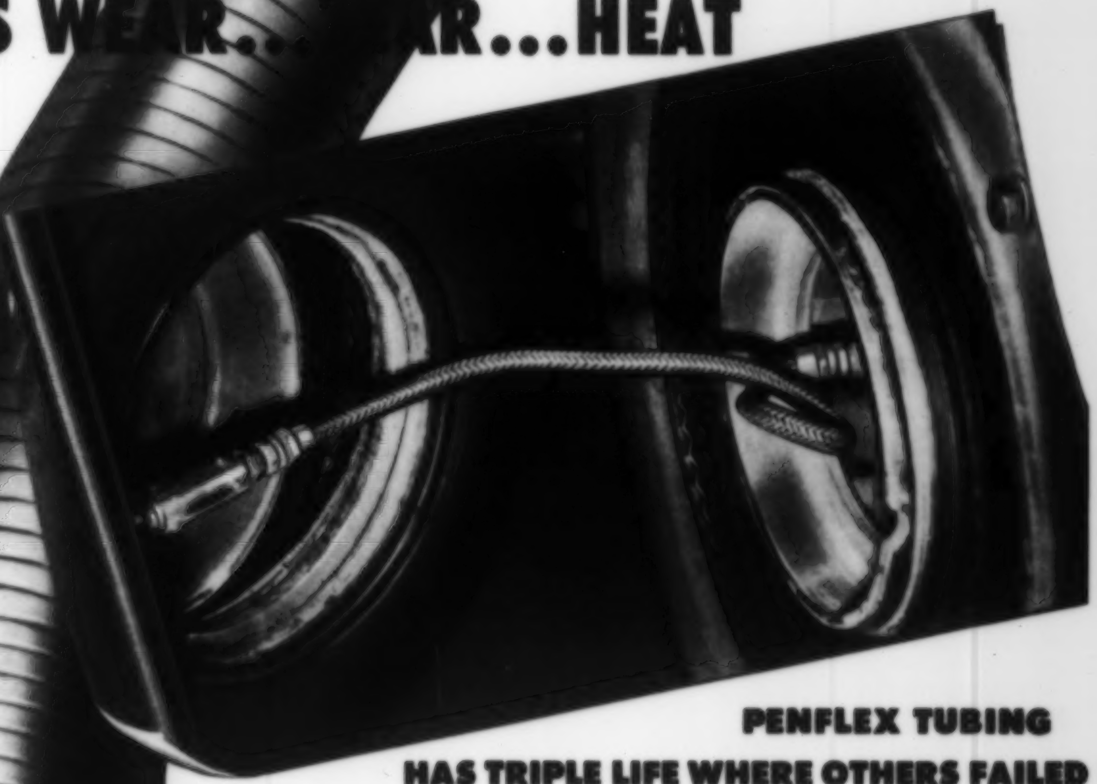


STANDS WEAR...TEAR...HEAT



PENFLEX TUBING
HAS TRIPLE LIFE WHERE OTHERS FAILED

Heat . . . pressure . . . constant flexing were the operating conditions on the "watch-case moulds" in a large tire plant. Many other metallic hoses had been used. Pre-mature failures resulted in a call to Penflex.

"Flexineering" went to work. The situation studied. The proper type of Penflexweld wire braided hose installed. Now, these Penflex products have built up a consistent record of lasting three to four times longer than the previous products used.

When specifying corrugated tubing or flexible metallic hose be certain you decide on the best. Let Penflex engineers show you how "Flexineering" can save you time, maintenance, production and money. They are ready to supply you with a complete line of four wall interlocked and seamless welded corrugated flexible tubing in sizes from 1/8" to 30" I.D. Write today for the new fact book on flexible tubing.

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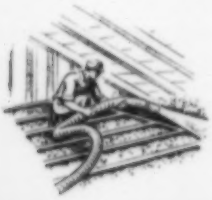

PENFLEX

HEART OF INDUSTRY'S LIFE LINES

Assembly Costs Go Down

...WHEN
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ARE SPECIFIED

In assembling units equipped with Bunting Bronze Bearings there is no bearing to be pressed against a shaft shoulder no lock nut nor washer to hold the bearing and no outside end cover or enclosure.

Preparation of parts for assembly of a unit equipped with bearings and the actual assembling operations often add serious costs which can be eliminated by the use of Bunting Cast Bronze Bearings. The assembly of a unit equipped with Bunting Bearings is the simplest, easiest and most economical bearing assembly possible.

It will pay you to investigate the cost reductions made possible by the use of Bunting Cast Bronze bearings in your product. There is a Bunting engineer near you for consultation, or write our Product Engineering Department at Toledo.

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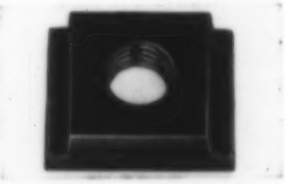
to lubricate the upper bearing on the vertical shaft. Reducer is applicable to agitators, mixers, circulators, pumps, washers and other vertical type drives. Made by **Philadelphia Gear Works,** Erie Ave. and G St., Philadelphia 34, Pa.

For more data circle MD-118, Page 215

Clinch Nut

Line of low cost clinch nuts is made to close tolerances for precise applications. All machine screw sizes from No. 6 to ⅜-in. are available. Made by **Jacobson Nut Mfg. Corp.,** Kenilworth, N. J.



For more data circle MD-119, Page 215

Slip Clutch Assembly

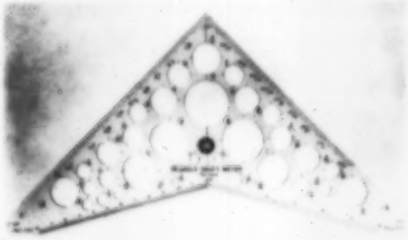
Precision slip clutch assembly, in which torque is adjustable, transmits torque from ¼ to 10 oz-in. as required through three small ground cork faces. The gear face will slip continuously when the set static friction is exceeded. Assembly is designed for basic shaft sizes of ⅛, 3/16 and ¼-in. and has stainless steel setscrews for holding and sub-drill holes for fixed pinning as desired. A wide range of gears is available. Standard stock pitches are 48, 64, 72 and 96 pitch in 20-deg pressure angle in stainless steel or aluminum. Made by **PIC Design Corp.,** 160 Atlantic Ave., Lynbrook, L. I., N. Y.

For more data circle MD-120, Page 215

ENGINEERING DEPARTMENT EQUIPMENT

Drafting Template

Triangle-Draft Meter is composed of a 10-in. 45-90 deg triangle, combined 30 and 60-deg angles, a 10-in. graduated protractor, scales in 1/32-in. and 1/16-in. divisions, a lettering guide, and a circle template with 33 circle guides ranging from 3/32 to 1½ in. in diameter. Made of 0.075-in. acrylic and vinyl plastic laminations, it is rigid, durable, ductile and shatterproof. Graduations lie close to drawing surfaces, eliminating the possibility of parallax lines. Instrument has parallel lettering guide spacers of ⅛, 5/32, 3/16 and ¼-in. A knob facilitates lifting. Made by **Alvin & Co.**, Windsor, Conn.



For more data circle MD-121, Page 215

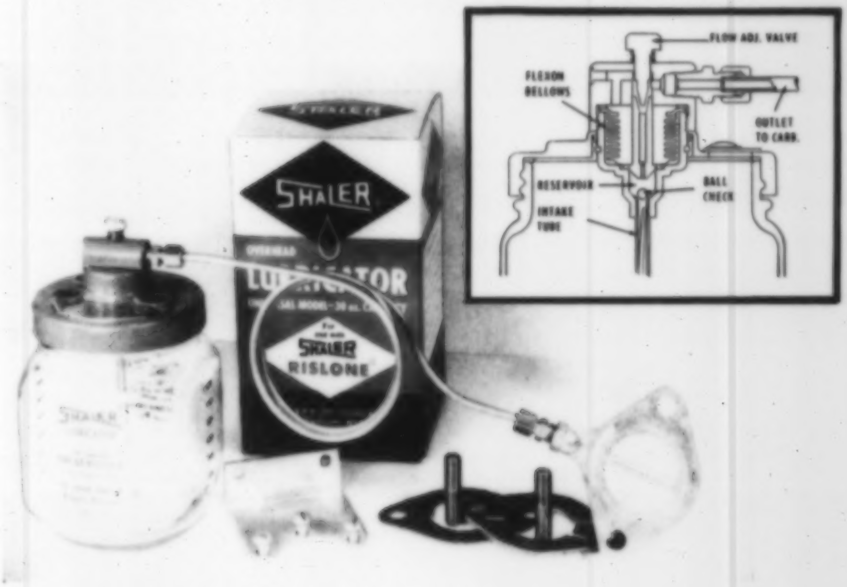
Drawing Instrument

Operation of the Math-a-graph mechanical drafting instrument is based on a mechanical linkage which transforms orthographic views into three-dimensional drawings by means of tracing. The instrument is easily adjustable to produce drawings in isometric, dimetric or trimetric positions. Drawings can show cutaway sections and exploded or transparent views as well as the outward appearance of an object. The machine consists of a track mounted on the vertical arm of an L-shaped piece of plastic which slides horizontally along another metal track. The vertical wood-

(*Continued on Page* 278)

FLEXON BELLOWS Design Briefs

Overhead Lubricator Design Depends on Flexon Bellows For Fluid Flow Control



FLEXON OFFERS THE COMPLETE BELLOWS SERVICE

Flexonics Corporation manufactures a complete range of bellows and bellows assemblies in brass, bronze or stainless steel for vacuum equipment, thermostatic devices, pressure controls, packless valves, pneumatic instruments, hydraulic mechanisms, rotating shaft seals and many other services.

FLEXON BELLOWS

The Flexon Bellows Design Guide gives valuable application and design information. Write for your copy.

● The Shaler Lubricator, manufactured by The Shaler Company, Waupun, Wisconsin is a device for feeding lubricant through the intake ports of internal combustion engines. It is designed to provide maximum lubrication when the engine is under load at low vacuum.

To make the unit sensitive to variations in intake manifold pressure, a ⅝" I.D. Flexon brass bellows assembly is employed in the operating mechanism. The bellows is subjected to a maximum vacuum of 25" of Hg. with a normal operating vacuum of 8" to 11". Vacuum is pulsating with variable frequency. It must withstand a temperature range from —35° to 200° F.

The Shaler Company has standardized on Flexon Bellows because they provide the dependable performance that keeps customers sold. You can put this kind of dependability to work for you if you specify "Flexon Bellows." For specific recommendations, send an outline of your requirements.

Flexonics Corporation
FLEXON BELLOWS DIVISION
1339 S. THIRD AVENUE ● MAYWOOD, ILLINOIS
FORMERLY CHICAGO METAL HOSE CORPORATION
Manufacturers of flexible metal hose and conduit, expansion joints, metallic bellows and assemblies of these components.
In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ontario

Flexon identifies products of Flexonics Corporation that have served industry for over 53 years.

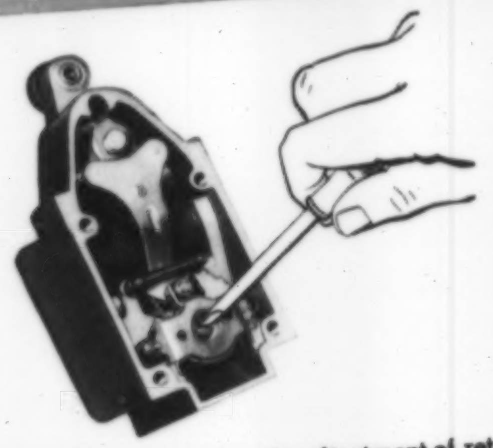
YOU GET eleven CONTACT ARRANGEMENTS IN one

80 DEGREES OVERTRAVEL
11 CONTACT ARRANGEMENTS
SIMPLE ADJUSTMENT
OIL TIGHT
EASY STOCKING
EASY MOUNTING
RUGGED MECHANISM
CLASS 9007
LIMIT SWITCH
RATING-AMPS
SQUARE D COMPANY

Write for Bulletin SM-239
Address Square D Company,
4041 North Richards Street,
Milwaukee 12, Wisconsin

SQUARE D COMPANY

WITH THIS NEW MACHINE TOOL LIMIT SWITCH!



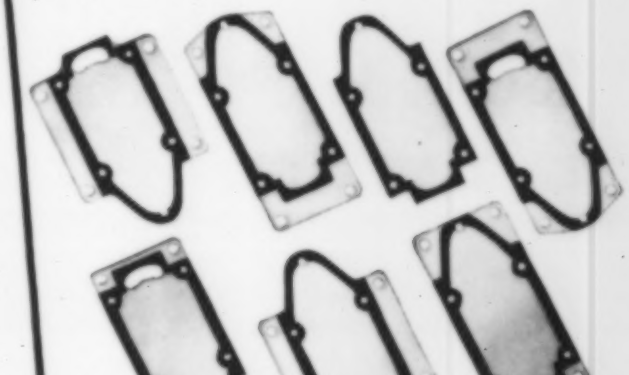
Versatility Plus! Simple adjustment of return spring positioning plate determines position of the movable contact in the "free" position. Equally simple adjustment of latches makes switch either single acting, or double acting with neutral position . . .

11 switches in 1 . . . all you need is a screw driver!

80°
OVERTRAVEL

Adjustable! Operating lever arm position is continuously adjustable and provides up to 80° overtravel unless limited by enclosure. An outstanding Square D design feature.

No Inventory Problem! Square D's basic switches and lever arms are separately packaged for your stocking convenience. A moderate stock covers a multitude of possible combinations.



Easy Mounting! Square D provides seven different base plates, plus side mounting holes. It's easy to mount switches in a variety of positions.

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Use FAIRFIELD GEARS

Protect

the POWER and PERFORMANCE

OF YOUR PRODUCT

There's hardly a power driven machine built that doesn't depend on gears for its get-up-and-go—its productivity—and very often *its reputation.*

No wonder, then, why more and more manufacturers insist on Fairfield Gears for their QUALITY—and also for their mass-production ECONOMY.

No matter what type or size of gears you require, it will pay you to check with Fairfield first. Take advantage, too, of Fairfield's helpful engineering services. *Your inquiry will receive prompt attention.*

Ask for interesting, illustrated bulletin.

Fine Gears Made to Order

SPUR GEARS—Straight, helical, and internal. Sizes from 16 pitch, 1½" dia., to 1½ pitch, 36" dia.

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SPLINED SHAFTS—Lengths to 52". Diameters from 1" to 6".

DIFFERENTIALS—10,000 to 300,000 inch pounds capacity.

Note: All sizes above are approximate.

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for FINE GEARS

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Engineering Equipment

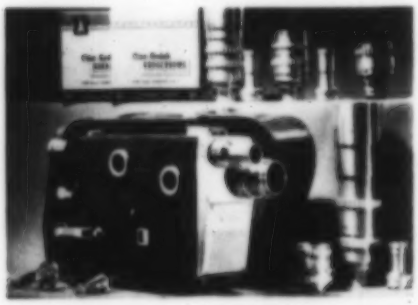
(*Continued from Page 275*)

en track accommodates two ball bearing slides located on the ends of the two crossed Y-arms which carry the tracer and the marker. As shown, the new drawing is made at the left of the original. The original, mounted on cardboard, is moved to various locations to produce the three-dimensional drawing. Connecting the machine's marker to a pantograph provides for enlarging or reducing the drawing to any size. An extension arm separates the tracer and marker an additional 10 in. for use on large drawings. Made by **Wilkinson Co.**, P. O. Box 638, Arnold, Md.

For more data circle MD-122, Page 215

Movie Camera

Cine-Kodak K-100 16-mm roll-film movie camera has a prestressed spring-power motor which permits exposure of 40 ft of film at one winding. A dial indicates the amount of film which can be run before rewinding. It also has a full-size one-for-one telescopic viewfinder and a large speed-control governor. Speed range is 16 to 64 frames per second. The camera uses 50 or 100-ft rolls of single-perforated film for sound recording or standard double-perforated film. Equipped with a Kodak Cine Ektar lens, it also uses any auxiliary Cine Ektar lens in focal



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When you discuss solenoid valve requirements with an ASCO Engineer, you are benefiting from the design and development experience of half a century. The ASCO specialist can recommend the *right* valve for your needs because that leadership has resulted in the more than 1300 types of solenoid valves now available:

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And ASCO can supply you with standard, explosion-proof or water tight enclosures – Class A and Class H coils – a wide range of body materials including cast iron, brass, bronze and stainless steel.

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Electrically tripped
Bulletin 8015

Safety shut-off, no voltage release
Bulletin 8025

"Free handle" safety shut-off
Bulletin 8020

TWO WAY – FULL PORTED

Low pressure
Bulletin 8030

General purpose
Bulletin 8210A

Steam
Bulletin 8222

TWO WAY – SMALL PORTED

Midget, general purpose
Bulletin 8262

Fuel oil and gas
Bulletin 8268

Explosion proof
Bulletin 8269

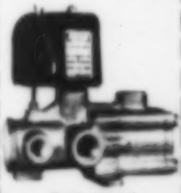
THREE WAY

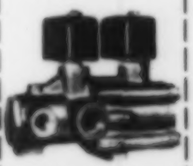
Pilot control of diaphragm or cylinder
Bulletin 8300

Explosion proof
Bulletin 8302

Midget, general purpose
Bulletin 8314

FOUR WAY


Single solenoid
Bulletin 8344


Dual solenoid
Bulletin 8344

Midget, general purpose
Bulletin 8345

CORROSION RESISTANT

Cylinder operated, Saunders body
Bulletin 8336

Compact Saunders type
Special Bulletin 8336

Three way
Special Bulletin 8300

Cylinder operated, many body materials
Bulletin 8338

PILOT CONTROLLED

Water and gas
Bulletin 8333

Three way
Bulletin 8331

Expansible sleeve
Bulletin 8335

Steam
Bulletin 8334

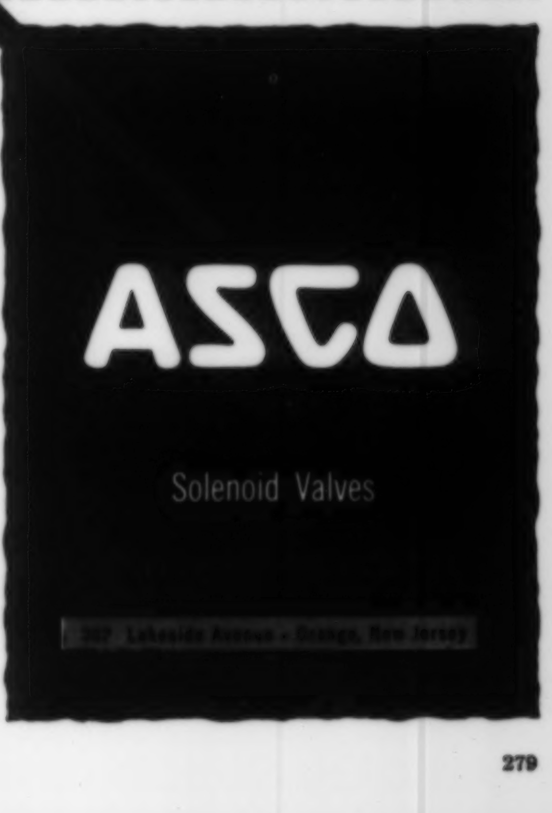
SPECIAL PURPOSE

Cylinder operated, sanitary
Bulletin 8337

Pressure operated, manual reset
Bulletin 8035

Bulk loading, electrical interlock
Bulletin 8023

Drain valve, washing machine
Bulletin 8339



how a Lubrication Engineer converted to
Norgren Micro-Fog Lubrication
of bearings and gears on milling machine

RESULTS • eliminated serious heating problem
• improved milling accuracy
• reduced number of rejects

A leading manufacturer of electrical automotive equipment uses machine illustrated for milling slots in cast iron distributor housings. When mill and power heads were packed with grease the machine ran so hot after an hour's operation that guide rods stretched, causing inaccuracies in location of milled slots.

A Norgren Lubro-Control Unit, Model 3765 FRV-2, was installed.

RESULT: Now, after 8 hours of continuous operation the machine operates at a temperature only slightly above ambient ... milling accuracy has been greatly improved and the number of rejects substantially reduced.

Norgren integral Filter-Regulator unit (Model 5A2GG) filters grit, pipe scale and moisture from the compressed air, prevents contamination of oil supply and reduces main line pressure to proper working pressure; a Micro-Fog Lubricator (Model 30-41-2S) creates an air borne oil fog, controls rate of oil feed, and assures thorough, dependable lubrication of gearing and bearings in mill and power heads. A solenoid valve starts and stops the Micro-Fog lubrication system as the machine is turned on and off.

DESIGNERS ... you can add important operating features to your machine tools with Norgren Micro-Fog lubrication ... types and sizes of lubricators for small and large machines, with capacities up to 1000 bearing inches.

For details on above and other machine tool applications and technical information on system design, write for Norgren Blueprints MF10 through MF18.

C. A. Norgren CO.
3442 So. Elati, Englewood, Colo.

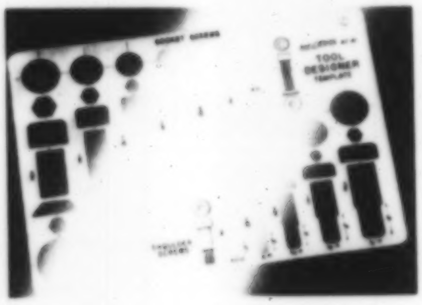
Oil Fog Lubricators • Pressure Regulators • Air Filters • Valves • Hose Assemblies

lengths from 15 to 152 mm. The camera can make single-frame exposures, and it has an auxiliary hand crank which permits backwinding. An external electric motor can be used to drive the camera. Made by **Eastman Kodak Co.**, Rochester 4, N. Y.

For more data circle MD-123, Page 215

Screw, Wrench Template

Seven sizes of socket screws from No. 10 to $\frac{5}{8}$-in. thread diameter and five shoulder screw sizes from $\frac{1}{4}$ to $\frac{5}{8}$-in. shank diameter can be drawn with the No. 81 template. All sizes have cutouts for respective head diameter and wrench size, front elevation and top view. With a total of 69 cutouts, template is made of 0.030-in. matte finish mathematical quality plastic. Size is $8\frac{1}{2}$ x 6 in. Made by **Rapidesign Inc.**, P. O. Box 592, Glendale, Calif.



For more data circle MD-124, Page 215

Photosensitive Aluminum

Photodized aluminum plates are designed for producing engineering, gaging and inspection templates and other similar applications. Photodized plates can be processed in subdued light, or if done quickly, in normal room light. Exposure can be made through photographic film negatives, glass charts or tracing vellum. Plate is covered with the transparent master, exposed to ultra-violet light such as that supplied by a sun lamp, immersed in developer, then washed in running tap water. Made by **Metalphoto Corp.**, 2903 E. 79th St., Cleveland 4, O.

For more data circle MD-125, Page 215

here's typical example of how manufacturers reduce maintenance costs and protect equipment against air line contaminants

An automotive electrical equipment manufacturer uses a Norgren Automatic-Drain Filter, Model 11,200-2(25), to protect bearings and component parts of a 9/16" automatic screw machine against air line contaminants.

with

NORGREN AUTOMATIC-DRAIN FILTER

Norgren Automatic-Drain Filter (¼", ⅜", ½" sizes) for air tools, air cylinders and Micro-Fog Lubrication systems offer these advantages:

1. Removes abrasive grit and pipe scale.
2. Solids are filtered out before air enters drain chamber, reducing possibility of plugging drain mechanism.
3. Removes corrosive moisture.
4. Drains collected moisture automatically.
5. Discharges only under full load to reduce wear and loss of air.
6. Drain operates independently of air pressure fluctuation and air flow.
7. Prevents contamination of oil supply.
8. Low pressure drop.
9. Reduces air line maintenance operations.
10. Cuts air equipment repair costs.

Flow: 0 to 35 cfm.

Pressure: 30 to 150 psi.

WRITE FOR COMPLETE INFORMATION

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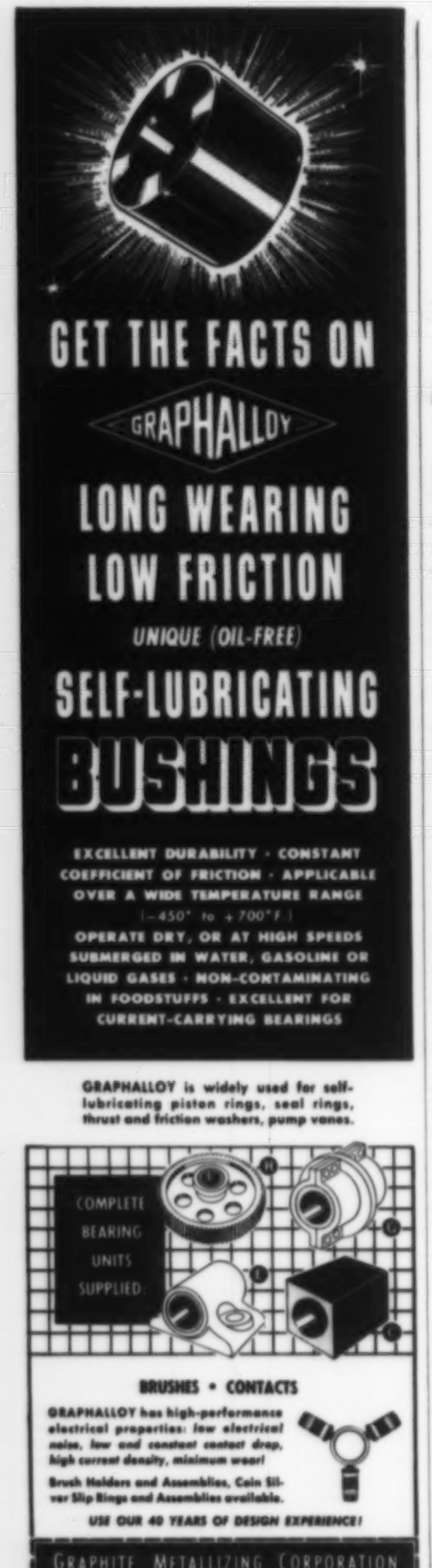
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Recent Books

Engineering Metallurgy. *By E. M. H. Kips, head, metallurgical laboratories, Philips Works, Eindhoven, Holland; 266 pages, 6 by 9 inches, clothbound; published by N. V. Philips Gloeilampenfabrieken, Eindhoven, Holland; distributed by Elsevier Press Inc., Houston, Tex.; available from* Machine Design, *$6.25 postpaid.*

Drawing upon American and European sources for data, this book presents a practical combination of metallurgy with properties and strength of materials. Characteristics of materials which affect design and performance are emphasized. This book aids in understanding the basic nature of practical processes and the important changes which occur during manufacture.

In seven chapters, subjects covered include mechanical properties of metals and alloys, corrosion, phase diagrams and their significance, alloys of iron with carbon and other metals, nonferrous metals and alloys, heat treatment, and working and joining of metals.

•

Acoustics. *By Leo L. Beranek, associate professor of communication engineering, Massachusetts Institute of Technology; 491 pages, 6 by 9 inches, clothbound; published by McGraw-Hill Book Co. Inc., New York; available from* Machine Design, *$9.00 postpaid.*

This textbook is designed for the engineer or scientist who works with acoustics. Subjects covered in 13 chapters include dynamic analogies, directivity patterns, acoustical circuits, loudspeaker enclosures, sound transmission through structures, noise reduction, speech communication and psychoacoustic criteria. Theories of acoustics are developed logically from basic equations and their solutions through loudspeakers and microphone design, noise reduction and room acoustics. Included are equations governing propagation of sound in free space and standing waves in enclosures.

Included in appendixes are decibel conversion tables and conversion factors.

•

Industrial Design. *By Harold Van Doren, industrial designer; 393 pages, 6½ by 10 inches, clothbound; published by McGraw-Hill Book Co. Inc., New York; available from* Machine Design, *$6.50 postpaid.*

This book, now in its second edition, covers the field of industrial design from preliminary research and analysis, visualization and rendering, to model-making and consumer testing. It outlines principles, techniques and procedures to follow in preparing mass-produced products for a variety of markets. Design problems covered in the book fall into four main groups: those involving consumer goods; commercial or service equipment; capital or durable goods; and transportation equipment.

•

Shell Molding and Shell Mold Castings. *By T. C. DuMond, editor,* Materials & Methods; *134 pages, 4 by 6½ inches, clothbound; published by Reinhold Publishing Corp., New York; available from* Machine Design, $2.00 postpaid.

This book is intended to enable

potential users of shell mold castings to evaluate the method of manufacture and to determine where and how such castings can be used to advantage. Subjects discussed in 10 chapters include definition of shell molding, advantages and limitations, costs, selection factors (materials, sizes, quantities, tolerances and finishes), designing, comparison with other processes, cores, the process and equipment, materials for shells and patterns, and applications of shell molding.

New Standards

Nomenclature of Gear Tooth Wear and Failure. *ASA B6.12-1954; 10 pages, 8½ by 11 inches, paperbound; available from American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y., $1.50 per copy.*

The purpose of this standard is to list, define and illustrate terms for the more common types of wear and failure of gear teeth. It applies only to metallic gears, the teeth of which have been produced by one or more machining operations, such as cutting, shaving, lapping and grinding.

Association Publications

ESL Bibliography No. 10: Bibliography on Unionization of Professional Engineers. *9 pages, 8½ by 11 inches, paperbound; available from Engineering Societies Library, 29 West 39th St., New York 18, N. Y., $2.00 per copy.*

This bibliography has been compiled for engineers, students and others interested in the problem of unionization. The 100 references listed are to publications from 1937 to 1954 which are in the Engineering Societies Library.

Manufacturers' Publications

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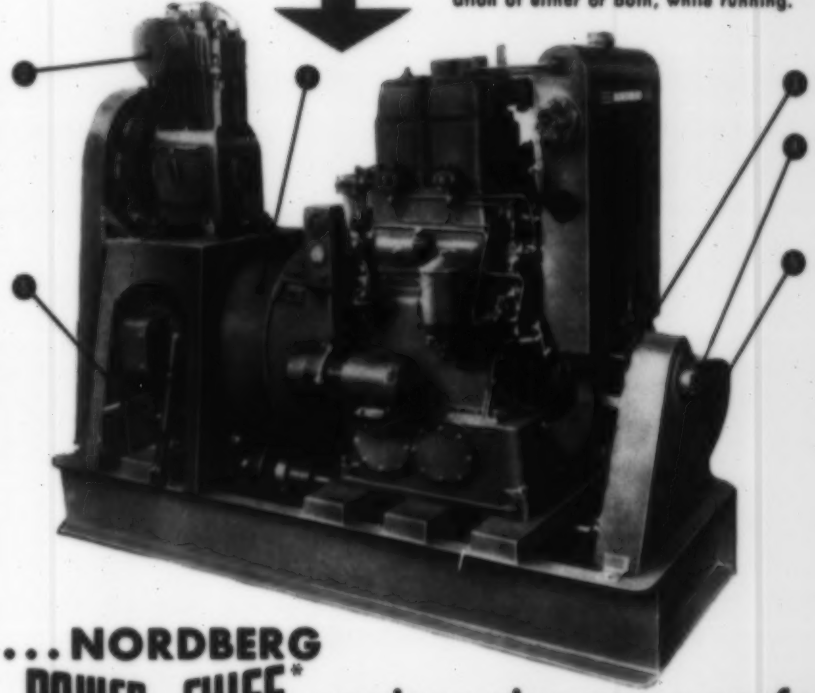

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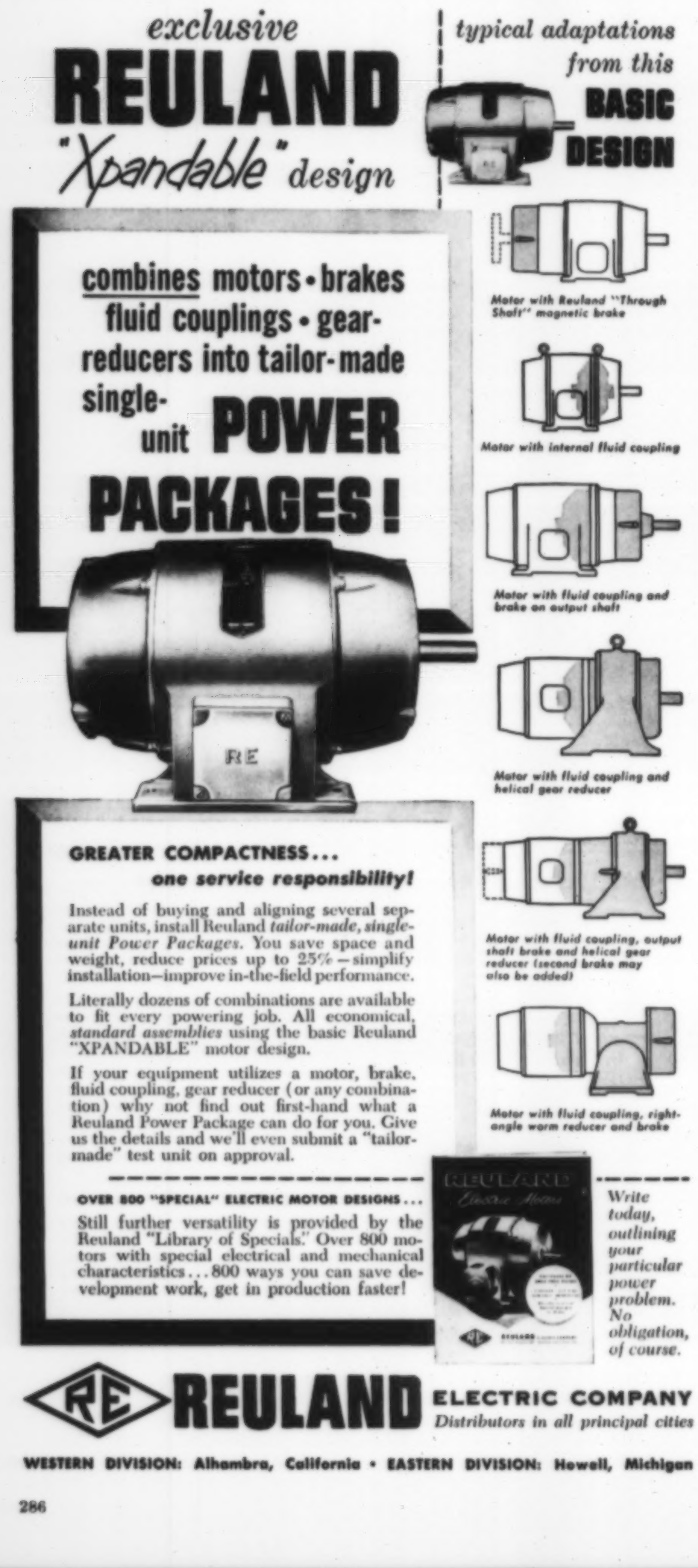

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paperbound; available from Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y. 25 cents per copy.

This booklet is devoted entirely to industrial applications for germanium crystals, rather than uses in communications. The four chapters cover relays and their applications, timing circuits, power supply applications and applications to industrial instrumentation.

Government Publications

Fortieth Annual Report of the National Advisory Committee for Aeronautics—1954. 84 *pages,* 9 *by* 11½ *inches, paperbound; available from Superintendent of Documents, U. S. Government Printing Office, Washington* 25, *D. C.,* 55 *cents per copy.*

This publication contains a review of NACA organization and activities. Its accomplishments and plans for the future are discussed under such headings as aerodynamics, power plants for aircraft, aircraft construction, operating problems and research publications.

•

NACA Technical Series. *Each publication is* 8 *by* 10½ *inches paperbound, side-stapled; copies available from National Advisory Committee for Aeronautics,* 1924 *F St., N.W., Washington* 25, *D. C.*

The following Technical Notes are available:

3336. **Review of Experimental Investigations of Liquid-Metal Heat Transfer**—115 pages.

3352. **Experimental Investigation of Misaligning Couples and Eccentricity at Ends of Misaligned Plain Bearings**—81 pages.

3368. **Analysis of Behavior of Simply Supported Flat Plates Compressed beyond the Buckling Load into the Plastic Range**—[illegible] pages.

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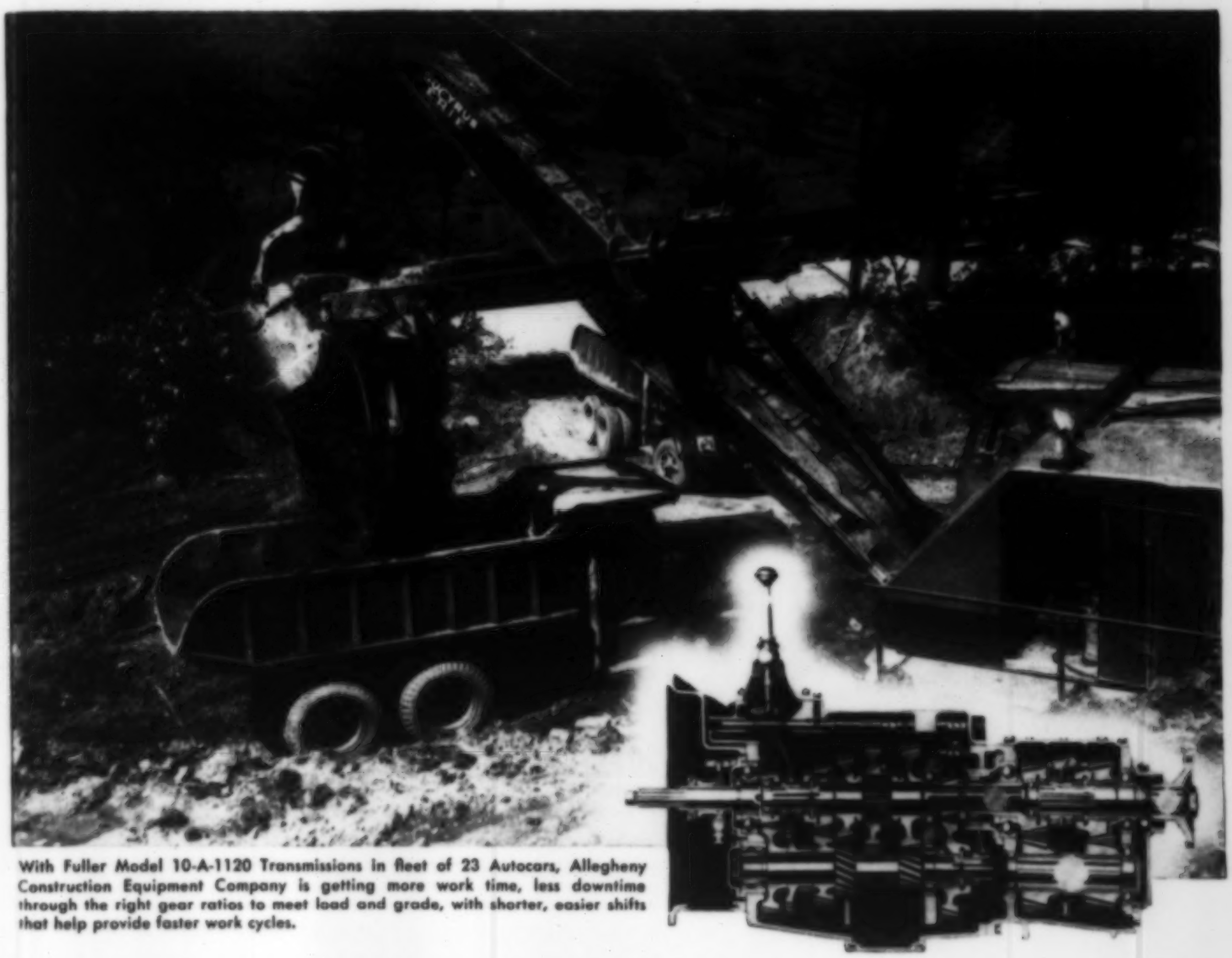

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Review of Surface Finish Literature

By John W. Sawyer
Bureau of Ships
Department of the Navy
Washington, D. C.

FOLLOWING is a subject index which refers to abstracts presented in the article, "Review of Surface Finish Literature," in the May issue of MACHINE DESIGN. Literature on the subject of surface finish published during 1952 and 1953 was abstracted.

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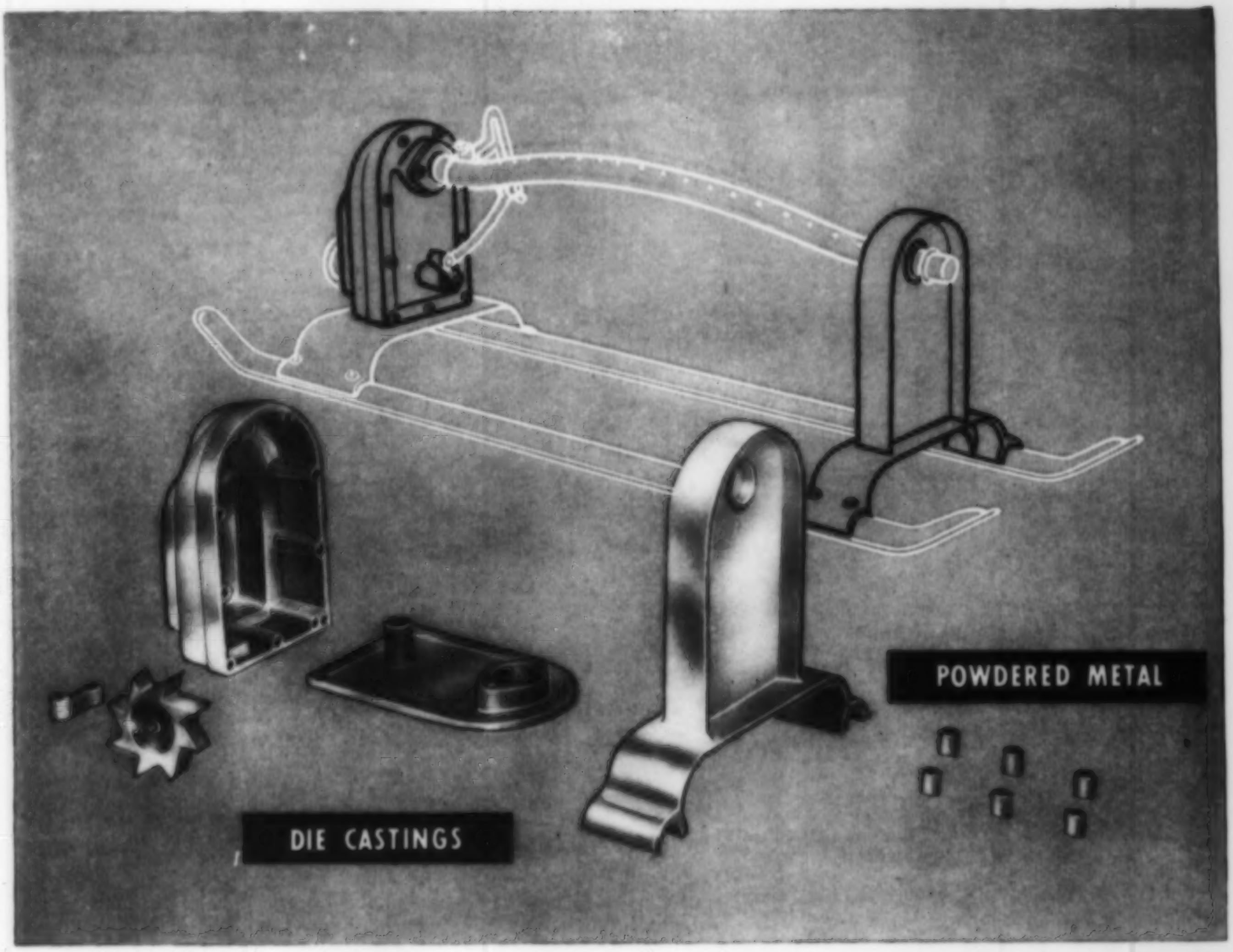

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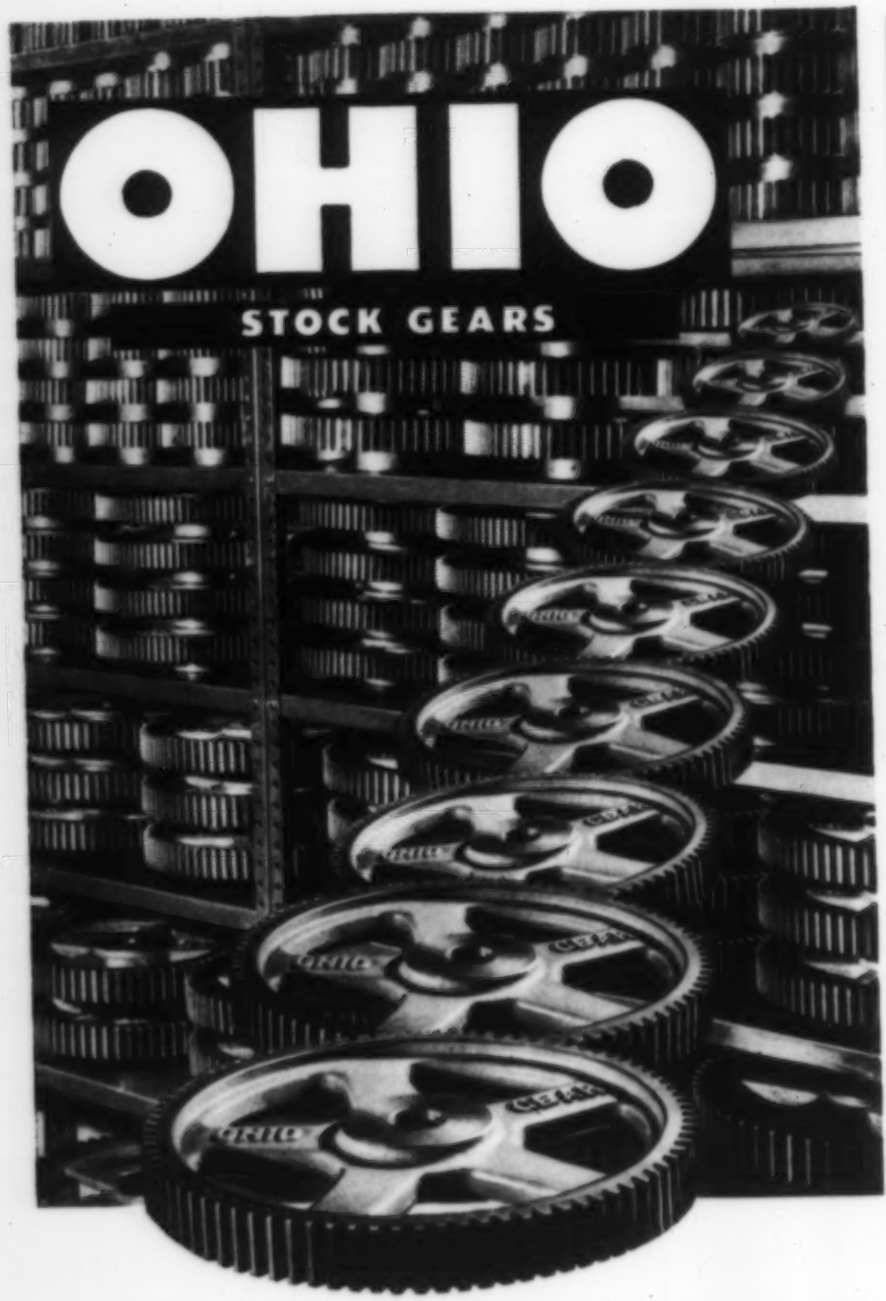

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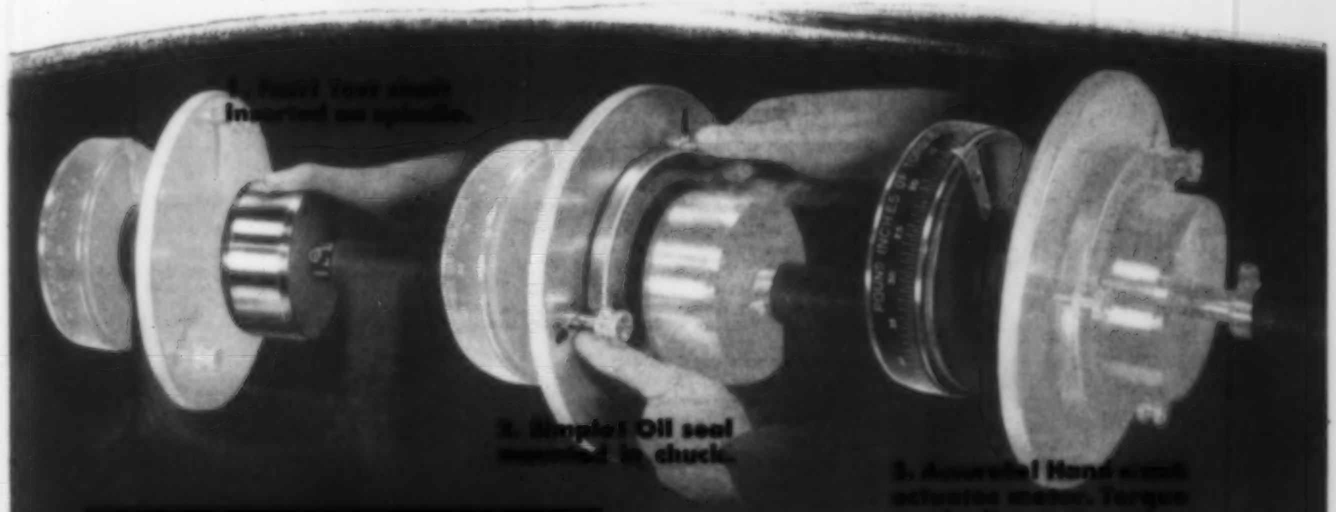
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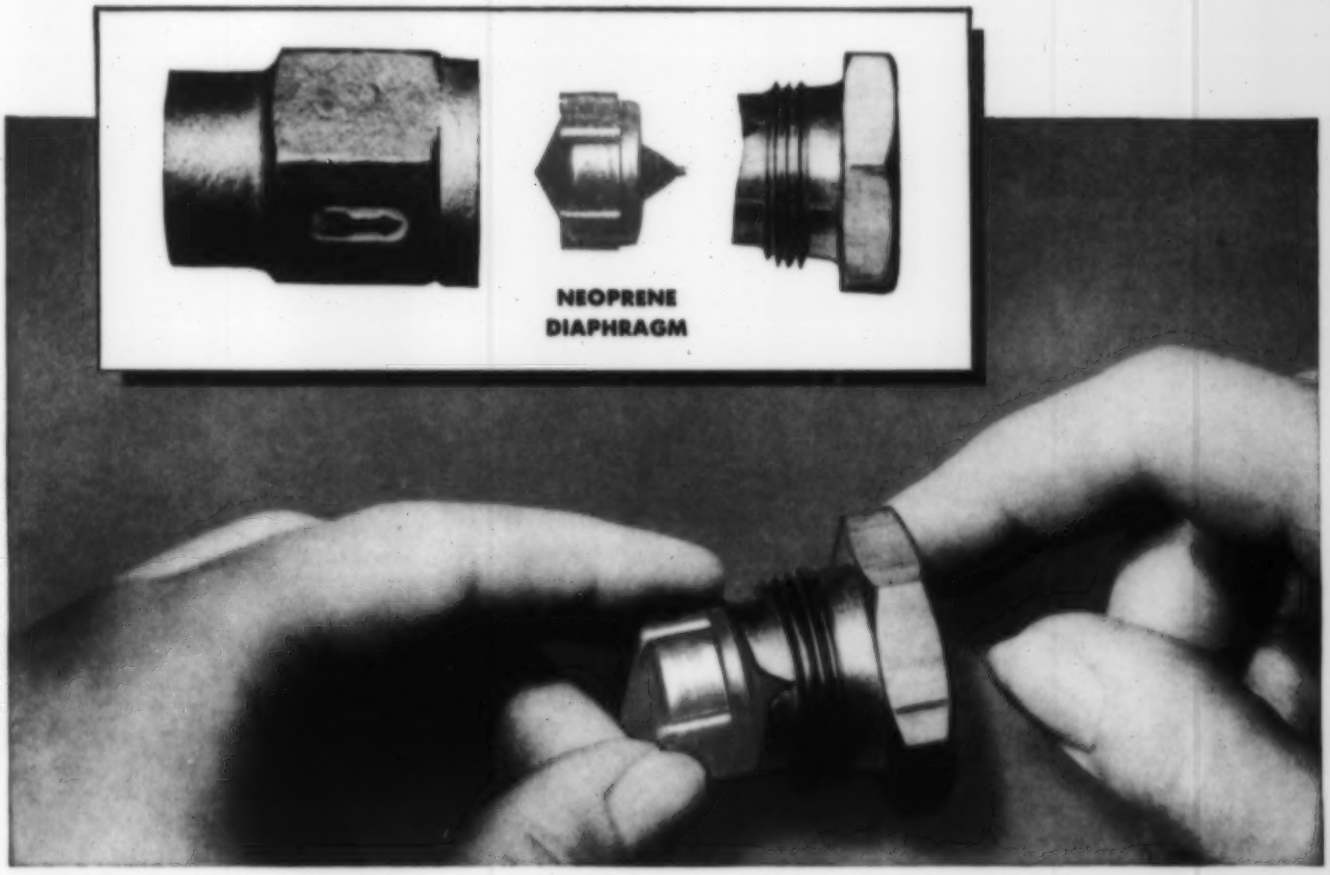

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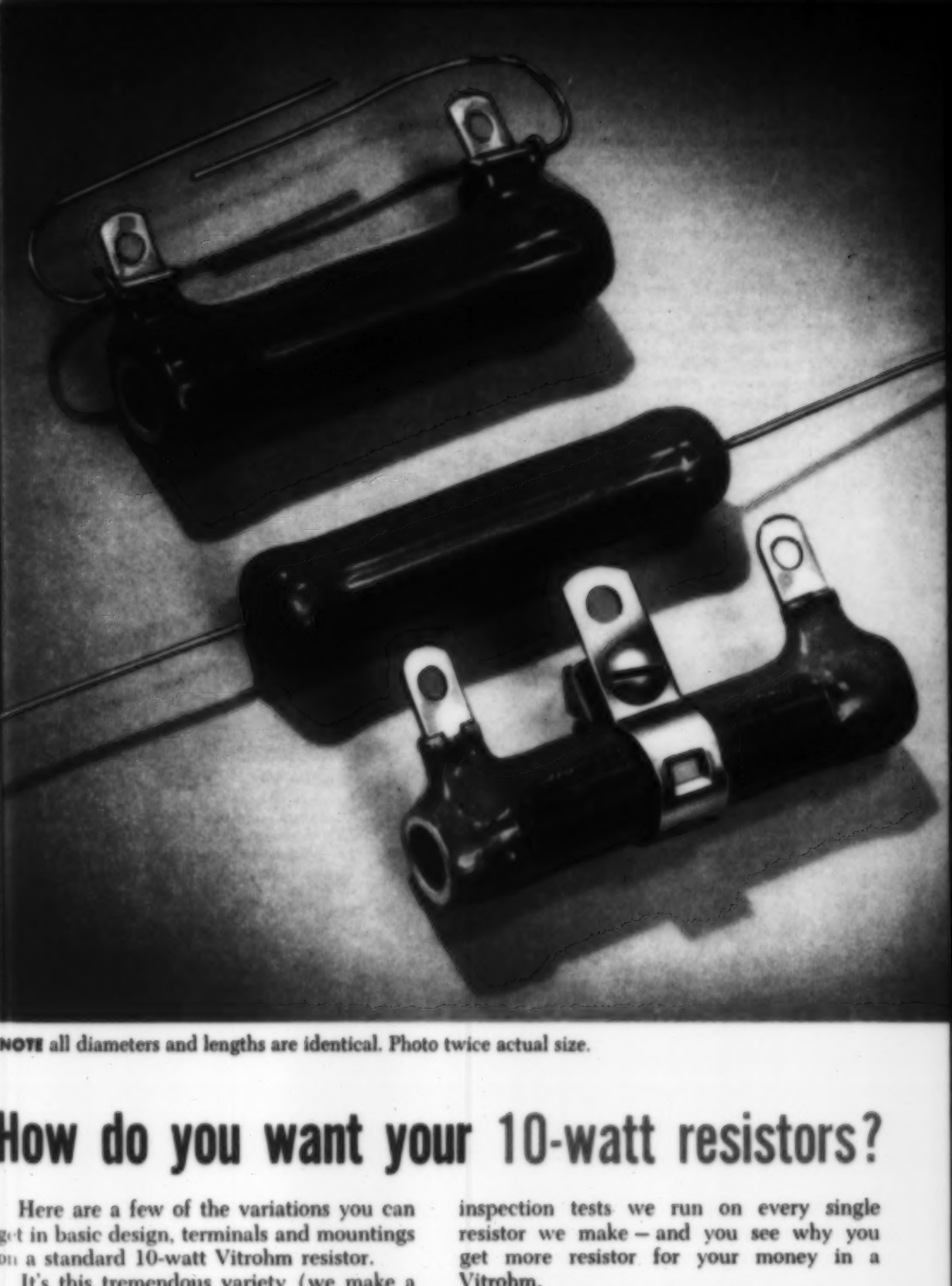

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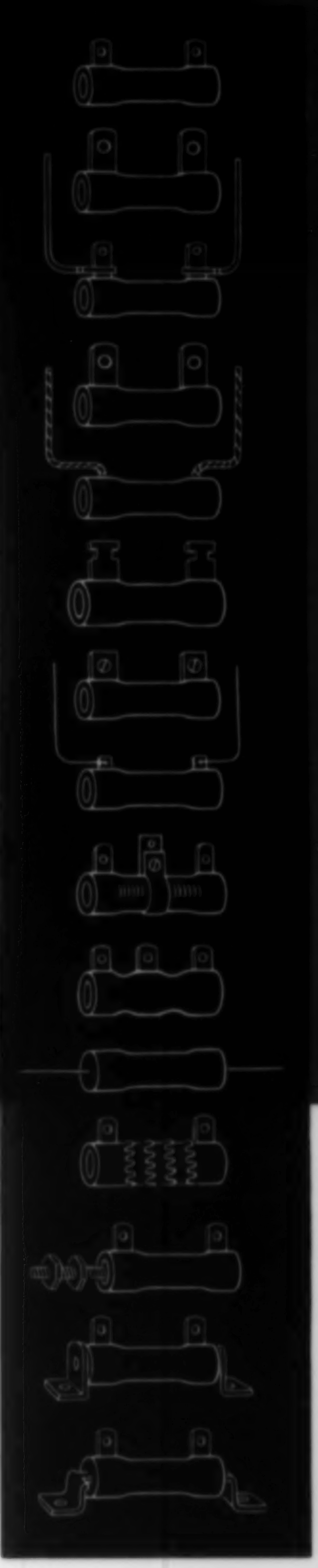

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This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series will be supplied on request. Address: Advertising Department, Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

NO. 13

COLOR MATCHING OF ANODIZED ALUMINUM ALLOYS

COLOR MATCHING, in the sense of "tone" or "shade," among the various aluminum alloys can be rather complicated. The degree of complication depends greatly upon the type of finish which is desired for the various alloys which might be used in making up an aluminum assembly.

Generally, the appearance of various wrought and cast alloys will vary slightly in the mill-produced condition because of different alloy constituents at the surface. The simplest way to achieve the most uniform color among the various alloys is to polish them mechanically. Practically all freshly polished aluminum alloys look alike. However, ordinary weathering or aging in industrial atmospheres will cause slight surface film reactions. The products of these reactions will differ for the various alloys. Generally, aluminum alloys retain a bright pleasing appearance despite extended exposure to the weather. A few alloys will darken upon weathering.

Alloys that contain silicon, such as 4043, and those that contain copper, such as 2024, are among the alloys which darken rapidly upon exposure in the unprotected condition. There is no way to prevent this except by anodizing, chemically coating or painting.

Chemical conversion coatings, while often providing satisfactory protection from the environment, are not usually suitable for decorative applications. If a good permanent color is important to a design, and if painting is not desirable, anodizing is necessary. In a situation such as this a very careful selection of alloys must be made before anodizing in order to obtain a good color match—or contrast if it is desired. All alloys will exhibit slight to marked color differences after being anodized. Some alloys are fairly close in anodized color, especially when the anodic coating is not too thick. Figure 1 shows both matching and contrasting anodized aluminum alloys.

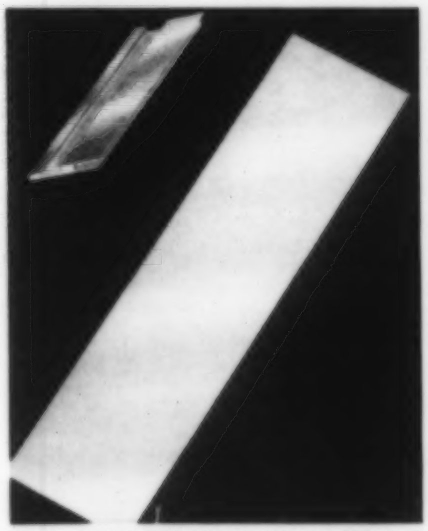

Fig. 1. Anodized 6063 extrusion alloy and 5005 sheet alloy lie side by side on a sheet of anodized 4043 sheet alloy which is quite dark. Notice that the 6063 and the 5005 match each other in color value but contrast sharply with the 4043.

A recognition of the technical principles which must be employed in the selection of the various alloys for color matching of their anodic coatings is of value in many applications of aluminum. In the architectural field alone the subject of color matching in anodized aluminum is assuming greater importance. Almost daily aluminum usage increases in such things as curtain wall construction. Table 1 lists many of the aluminum alloys in general use today and shows the approximate color matches obtainable through anodizing. For maximum color similarity slight variations in the anodizing process are necessary and should be established by the processor. The chemical compositions and tempers of the alloys are the basic reasons for differences in color after anodizing.

The commercially pure materials, such as 1100, EC, 1180 and the cladding material of Alclad alloy 2024, all exhibit relatively good color matches after anodizing. Those Alclad alloys which employ 7072 as the cladding, e.g. 3003, 3004, 5050, 6061 and 7015 will match well after anodizing. As a class, alloys containing magnesium provide relatively good matches, especially if the anodic coating is of moderate thickness. The magnesium content exerts a slight influence upon the color, but the purity of the alloy base is even more important. As a general rule, the higher the purity of the alloy base, the more transparent and the brighter the appearance of the anodic coating. Thus, anodized 5052 is brighter than anodized 5050.

Alloys containing copper, for instance 2014 and 2024, generally develop dark unattractive coatings when anodized in the annealed condition. The same alloys, when properly heat treated and quenched, may give relatively clear, attractive anodic coatings that will approximately match anodic coatings on alloys 1100 and 5005. A similar situation exists for 7075 alloy.

The high silicon alloys, such as No. 43 and No. 380 which are frequently employed in castings, present a very difficult problem since the silicon constituent darkens upon anodizing and, with sufficient anodic coating thickness, may be quite black. It is impossible to match such anodized casting alloys with most other aluminum alloys in the anodized condition. A match is possible with alloy 4043.

Aluminum casting alloys containing principally magnesium rather than silicon, on the other hand, match reasonably well with most other alloys. Casting quality and technique have an

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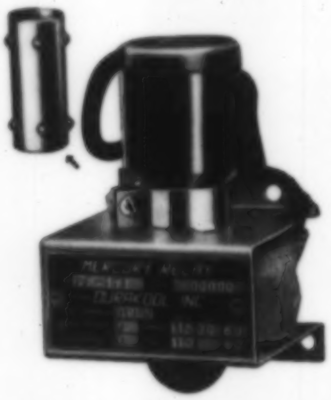

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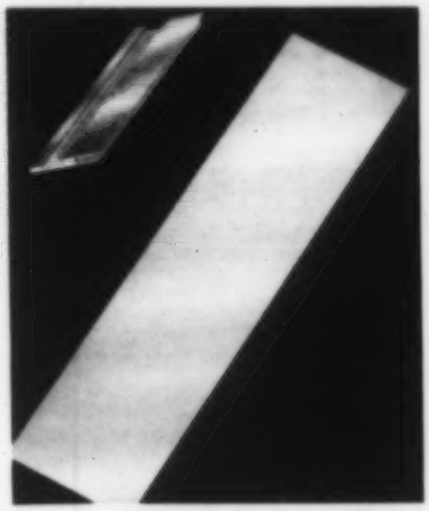

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DESIGNING WITH ALUMINUM No. 13 Continued

TABLE 1

APPROXIMATE COLOR MATCHES OF ANODIZED ALUMINUM ALLOYS

O = Relatively Good Matching   X = Better Matching

	Sheet and Plate Alloys																	Extrusion Alloys						Casting Alloys			
Sheet and Plate Alloys	1180	1100	2014*	2024*	Alclad 2024	3003	Alclad 3003	Alclad 3004	4043	5005	5050	Alclad 5050	5052**	6061	Alclad 6061	7075*	Alclad 7075	1100	3003	2024*	6061	6063	7075*	43	A214	A218	380
1180	X	O			O													O									
1100	O	X	O	O	X					O						O		X		O			O				
2014*		O	X	O						O								O		O					O	O	
2024*		O	O	X						O								O		X					O	O	
Alclad 2024	O	X			X													X									
3003						X													X								
Alclad 3003							X	X				X			X		X								O	O	
Alclad 3004							X	X				X			X		X								O	O	
4043									X															X			X
5005		O	O	O						X	O		O	X		O		O		O	X	X	O		O	O	
5050										O	X		O	O		O					O	O			O	O	
Alclad 5050							X	X				X			X		X								O	O	
5052**										O	O		X	O							O	O			O	O	
6061										X	O		O	X							X	O			O	O	
Alclad 6061							X	X				X			X		X								O	O	
7075*		O								O						X		O					X		O	O	
Alclad 7075							X	X				X			X		X								O	O	
Extrusion Alloys																											
1100	O	X	O	O	O					O						O		X		O			O				
3003						X													X								
2024*		O	O	X						O								O		X					O	O	
6061										X	O		O	X							X	O			O	O	
6063										X	O		O	O							O	X			O	O	
7075*		O								O						X		O					X		O	O	
Casting Alloys																											
43									X															X			X
A214			O	O			O	O		O	O	O	O	O	O	O	O			O	O	O	O		X	O	
A218			O	O			O	O		O	O	O	O	O	O	O	O			O	O	O	O		O	X	
380									X															X			X

* Heat treated and quenched   ** For relatively thin anodic coatings, i.e., not exceeding 20 min anodizing

even greater influence on anodizing characteristics than does the alloy composition.

Among the sheet and plate alloys it is almost impossible to match alloys containing manganese, such as 3003, with other alloys as far as color in the anodized condition is concerned.

Some examples of compatible pairs for anodizing are 5005 and 6063, 5005 and 6061, 1100 and Alclad 2024. Numerous other examples may be chosen based on the principles outlined above. Of special interest to designers and engineers who are concerned with building materials and architectural design, is the excellent color match which may be obtained in the anodized condition with the sheet alloy 5005 and the extrusion alloy 6063. Alloy 5005 is a magnesium-containing alloy (nominal 0.8% Mg) with strength and formability approximately equal to those of 3003 alloy. Alloy 6063 is the extrusion alloy which is employed almost universally in window frame molding and store front trim. Where an architect wishes to use an anodized sheet product close to an anodized 6063 extrusion, a definite clash in color will result if alloy 3003 is employed as the sheet material. However, alloy 5005 when employed in place of alloy 3003, exhibits an excellent color match with 6063 when both alloys are anodized to the same coating thickness.

The understanding and application of the principles affecting the colors of anodized aluminum alloys will provide the means for attractive architectural design work. These same principles will undoubtedly influence the choice of aluminum alloys for products outside the field of architecture.

Further information concerning the color matching of anodized aluminum alloys may be obtained from the Kaiser Aluminum sales office listed in your telephone directory, or through one of our many distributors. Kaiser Aluminum and Chemical Sales, Inc. *Executive Office:* 6677 Kaiser Building, Oakland 12, California; *General Sales Office:* Palmolive Building, 919 North Michigan Ave., Chicago 11, Illinois.

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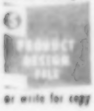

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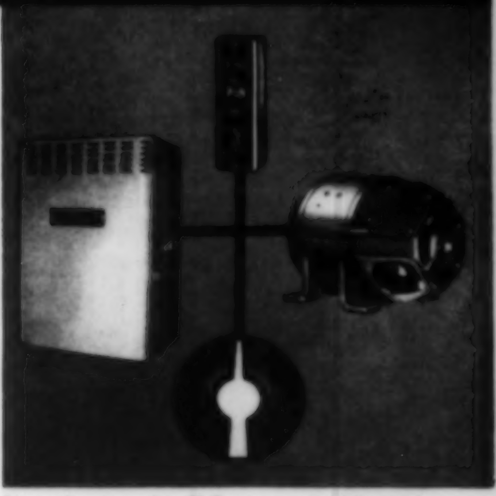

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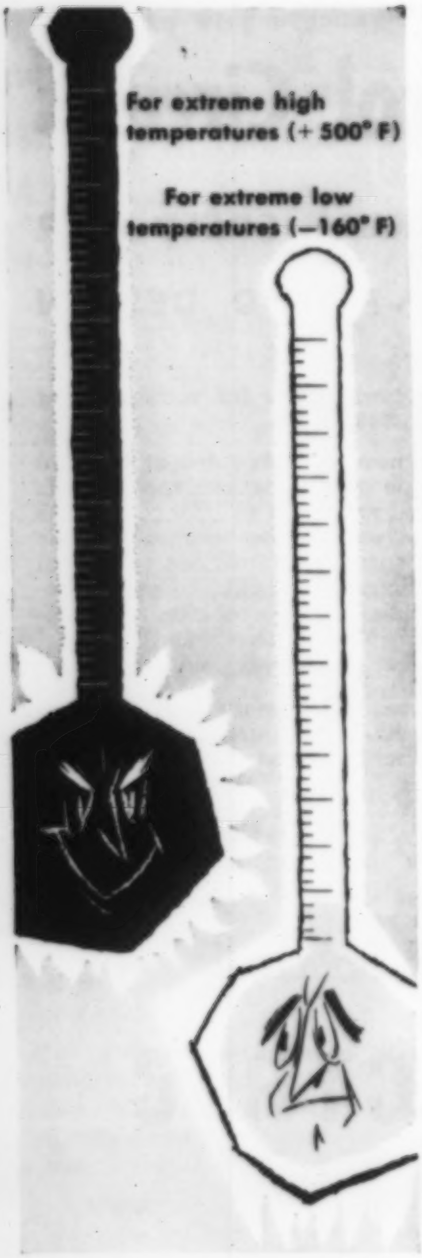
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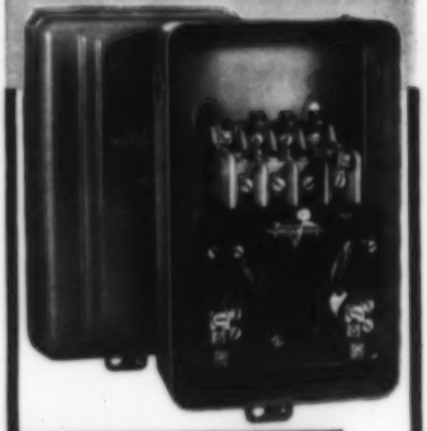

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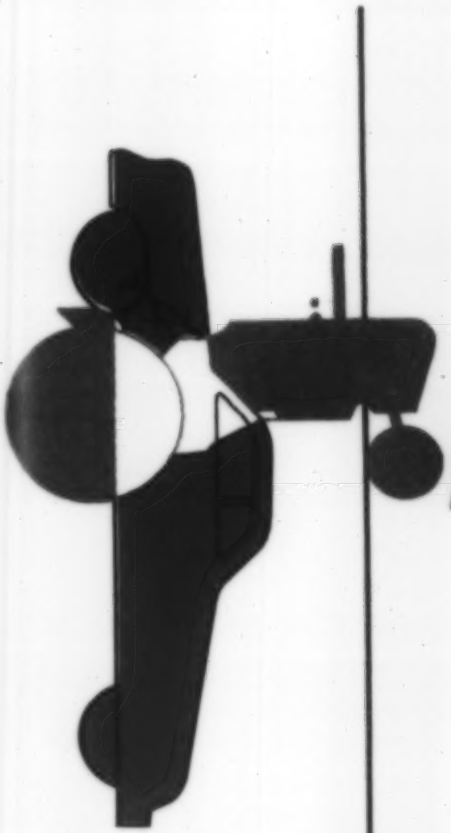

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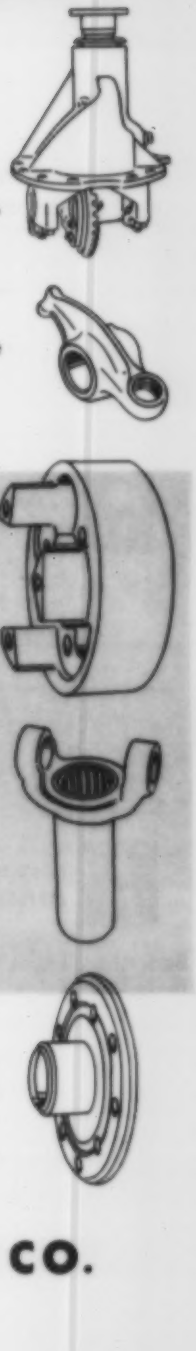

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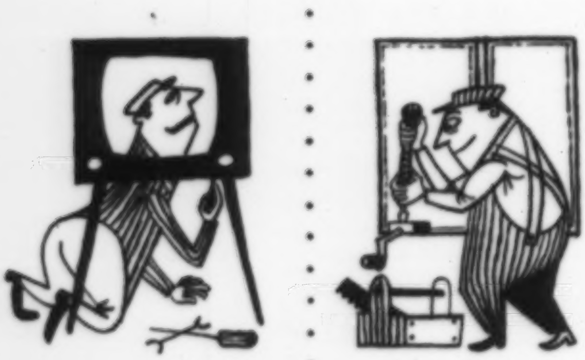
ECONOMY	**Albion's *pearlitic* malleable irons offer complete freedom of design for greater savings in machining time, the elimination of excess metal and lower finished part cost.**
PERFORMANCE	**Albion's *pearlitic* malleable irons afford unusually fine wear resistance with excellent bearing properties. Maximum rigidity and prolonged fatigue life offers outstanding endurance. Yield strength comparable to steel forgings plus good damping capacity.**
QUALITY	**Albion's *pearlitic* malleable irons have a fine, uniform grain structure that machines easily and accurately with exceptional mirror-smooth finishing qualities. Extremely adaptable to localized hardening for specific needs.**

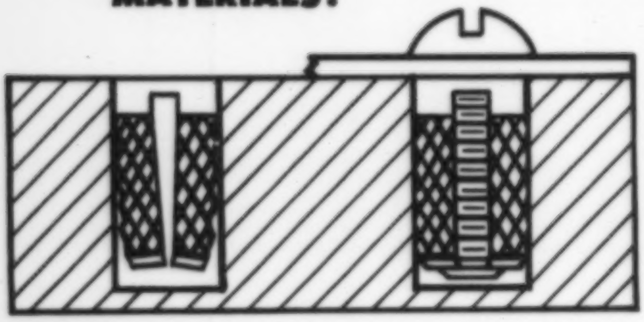
Laboratory Service... *whether you are designing new products or reviewing present production, Albion's Research and Development Laboratory facilities and competent engineering staff are ready to help you design better products that can be made at lower cost.*

ALBION MALLEABLE IRON CO.

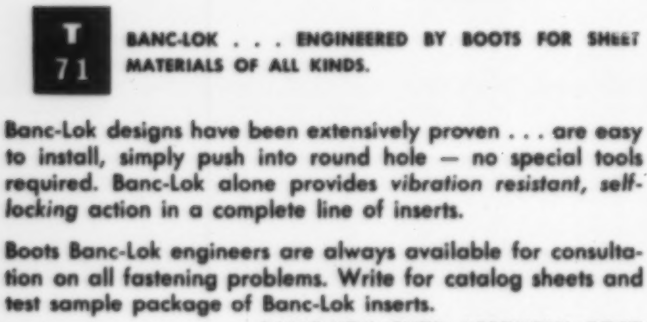
Albion, Michigan



BANC-LOK
THE FASTENER
FOR "DIFFICULT"
MATERIALS!



N 41 BANC-LOK . . . ENGINEERED BY BOOTS FOR PLASTICS, DIE CASTINGS, ALL SOFTER MATERIALS.



T 71 BANC-LOK . . . ENGINEERED BY BOOTS FOR SHEET MATERIALS OF ALL KINDS.

Banc-Lok designs have been extensively proven . . . are easy to install, simply push into round hole — no special tools required. Banc-Lok alone provides *vibration resistant, self-locking* action in a complete line of inserts.

Boots Banc-Lok engineers are always available for consultation on all fastening problems. Write for catalog sheets and test sample package of Banc-Lok inserts.

BANC-LOK CUTS ASSEMBLY COST
Patented. Patents Pending.

BOOTS
AIRCRAFT NUT CORPORATION
BANC-LOK DIVISION • 536 NEWTOWN TURNPIKE • NORWALK, CONNECTICUT

PROFESSIONAL VIEWPOINTS

The editorial "How To Create a Shortage of Engineers" stimulated an unusually high number of comments from our readers. In publishing a selection of these, below, we are omitting names of companies or individuals because of the delicate nature of some employer-employee relationships and because a few readers specifically requested that their communications be held in confidence. The comments are most welcome, and we take this opportunity to invite readers to send us their viewpoints, particularly on the engineer in relation to his job and to his profession.—ED.

To the Editor:

In your editorial "How To Create a Shortage of Engineers" you have with elegance set forth the situation that is becoming more and more evident. The unrest and dissatisfaction which exist in the engineering profession, due to poor wages and limited opportunities, are of terrific proportions.

I am a graduate mechanical engineer and honestly believe if I had known of these conditions I would have served an apprenticeship in one of the building trades. These trades are more lucrative and certainly not as confining.

My associates and I would like to express our appreciation for your presentation of the facts which are unknown to so many. Let's have more in the future along this line of thinking.

To the Editor:

Your fine editorial on "How To Create a Shortage of Engineers" hits between the eyes. I hope it does some good.

As a professional engineer (and a member of NSPE), a mechanical engineer (and a member of ASME), a machine designer (and a member of ASTE), a man of 52 years of age, with many years of experience in many companies—I will say you are (profanity) right. Now, if I hear of someone doing something about it, quickly and to the point, I'll join him and will bank my few dollars on it.

To the Editor:

The editorial "How To Create a Shortage of Engineers" certainly hit the nail on the head. I thought the editorial was so timely that I pasted it on the bulletin board for all to read. Needless to say I got a quick reaction from management. It was immediately taken down and I was reproved for using the bulletin board. The old saying certainly held true in this case—"It is the truth that hurts."

I am 30 years old myself and have 5 years machine design. I am a graduate mechanical engineer and registered professional engineer. There is only one other graduate engineer on the board

You buy right when you buy MACWHYTE wire rope products!

Wire Rope You are assured of getting the *right* rope at Macwhyte no matter what your equipment need . . . no matter how tough the going. There's no guesswork when you buy from a thousand and one types, sizes, and grades of wire rope.

Monarch Whyte Strand wire rope is available PREformed and Internally Lubricated, in Lang Lay, Regular Lay, and with Independent Wire Rope Core or Fiber Core. Ropes are made of Bright Steel, Galvanized Steel, Stainless Steel, and Monel Metal, and are supplied properly lubricated and fabricated to serve well under the severest service conditions. *Catalog G-16 is available.*

Slings Hundreds of sizes and types of Macwhyte wire rope slings are designed with the lightness, flexibility, and handling ease you need for efficient, low cost material handling. Three body styles are made: ATLAS Round-Braided, DREW Flat-Braided, MONARCH Single-Part. *Request Catalog S-8.*

Wire Rope Assemblies Many Safe-Lock wire rope assemblies are made in a wide range of sizes for machine parts, controls, and operating devices. Assemblies provide a unit of wire rope or aircraft control cable with permanently attached fittings made to specified length, size, load capacity. Assemblies are made to both industrial and aircraft standards. *Ask for Catalog 5201.*

MACWHYTE

WIRE ROPE · SLINGS · WIRE ROPE ASSEMBLIES

[illegible]

[illegible]

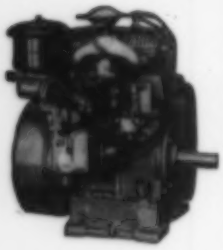
MACWHYTE
PREformed
WHYTE STRAND
WIRE ROPE

Recommendations on request

1078SW

An Interesting Small Engine Application to do a BIG JOB...

WISCONSIN-POWERED
Self-Propelled Grain Swather



This is the Model TF 2-cylinder Wisconsin Heavy-Duty Air-Cooled Engine that supplies complete power for the Owatonna Grain Swather illustrated above—3¼" bore x 3¼" stroke, 53.9 cu. in. displ., 8.7 to 14.6 hp., 1400 to 2600 rpm. Larger size swathers are powered by the Model VF4 V-type, 4-cylinder Wisconsin Engine.

Typical of the practical ingenuity employed by farm equipment designers and builders for the most advantageous utilization of engine power is this Owatonna Grain Swather, made by Owatonna Mfg. Co., Owatonna, Minn.

A unique feature of this Center-Delivery Grain Swather is that it opens up all types of grain fields without running down standing grain. Mechanically operated aprons at both ends of the machine carry the grain, as cut, to the center opening, depositing it in a compact, uniform swath for clean, easy combining. The floating cutter bar extends over the entire length of the machine, forward of the wheels.

A remarkable feature of this equipment is that an engine as small as a 2-cylinder Wisconsin furnishes the necessary power both for *propelling* and *operating* this big machine. It's an assignment that calls for heavy-duty Lugging Power and foolproof AIR-COOLING at temperatures up to 140° F. Here is a perfect example of *Power to Fit the Machine, Power to Fit the Job!*

Wisconsin Air-Cooled Engines are available in 12 sizes in 4-cycle single cylinder, 2- and 4-cylinder models, in a 3 to 36 hp. range.

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 46, WISCONSIN

A 8417-½

in our office and he is about 55 years old. This man is one of the best design engineers but I doubt whether he is making $7000 a year. He should be making a five-figure salary easily. What incentive is there for me to stay on the board if at 55 I am doing proportionally no better than he is?

Keep up the good work.

To the Editor:

Your editorial in April really hit it on the nose. During World War I, I studied engineering while in government service. Since 1928 I have been chief engineer at three prominent companies making special machinery, including 13 years in the present one.

Can't complain too much on my annual take the past three years, but when one of my men was taken for sales the company set his weekly earnings $20 per week above mine, as chief engineer.

Also, on a 50-hour week which means 55 hours pay for my men, one of my men draws 40 cents less per week than I do. Why is it that salary employees are not advanced in pay when hourly men under them receive an increase?

You really are on the right track.

To the Editor:

If there is such a great shortage, it seems to me engineers would be able to improve their lot through bargaining. Remember the law of supply and demand.

Frankly, I'm beginning to wonder if someone isn't trying to sell the engineers a bill of goods and make them feel important. We now have a title. "Men in Demand" but no more money.

They Say . . .

"It has been said that we, the citizens of the United States, can be divided into three classes:

The few who make things happen
The many who watch things happen
The overwhelming majority who have no idea what happens

In which class are you?"—GORDON B. CARSON, *director, Engineering Experiment Station, Ohio State University*

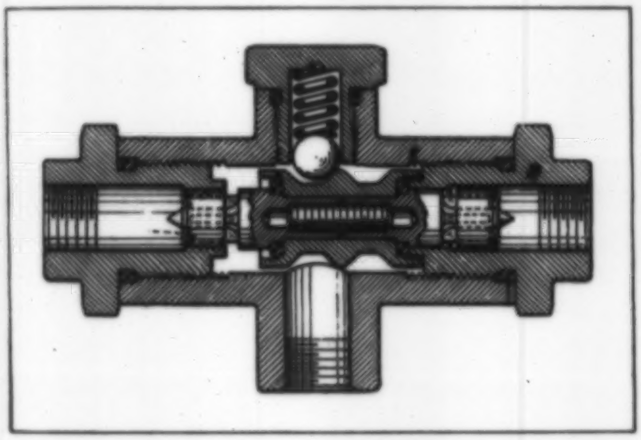
"One of the most powerful weapons in recruiting is to give the college senior a clear idea of where he will fit with the company once he starts to work. A well thought out indoctrination program introducing the young engineer to the profession via a variety of work assignments keeps the young engineer quite interested. The company doing the best job on this score has the best possibility of attracting young engineers."—E. F. UPTON JR., *chief product engineer, Brown Instrument Div., Minneapolis Honeywell Regulator Co.*

NOTEWORTHY

Patents

Shuttle Valve

Automatic switching between sources of fluid supply is accomplished with a pressure-sensitive double-ended valve designed to seat without leakage even under slight misalignment of the shuttle with the inlet ports. Sealing is provided by gaskets mounted in counterbores at each end of the shuttle. In the closed position of the valve, the deformation of the gaskets is limited by a stop arrangement. Because of the direction in which it is applied, fluid pressure cannot force the gaskets out of their recesses. Cylindrical guide extensions at each end of the shuttle maintain the assembly in alignment. A spring-loaded ball is arranged to seat in grooves in the shuttle to hold it in either of its two operating positions. *Patent* 2,685,296 *assigned to Parker Appliance Co. by F. C. Boosman.*

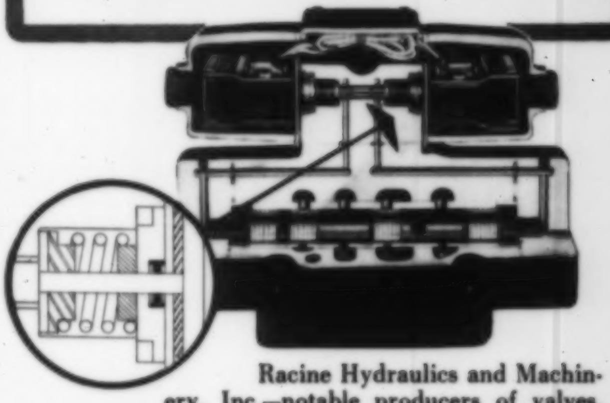


Rotational Speed Control

Automatic speed control of low-power shaft drives is accomplished by a centrifugal governor with a built-in friction brake. When shaft speed exceeds a certain critical velocity, weighted arms with projecting friction studs swing out and engage friction surfaces on the walls of the stationary housing. Degree of friction drag is proportional to the shaft speed. Disengagement of the friction studs from the stationary housing at rotational speeds below the critical velocity is maintained by a spring. Uniform governor action is assured by a cam and drive-bar arrangement which eliminates driving forces on the swinging arm pivots. Because of the construction of the unit, its operation is unaffected by gravity and it operates equally well in any position. *Patent* 2,685,946 *assigned to Bell Telephone Laboratories Inc. by W. Pferd and R. E. Prescott.*

(*Continued on Page* 312)

RACINE HYDRAULICS
"SOLVES SEALING PROBLEMS"
BY DESIGNING-IN
PALMETTO G-T RING®



Racine Hydraulics and Machinery, Inc.—notable producers of valves, boosters, pumps and pumping units—recently introduced their Twin Solenoid Pilot Operated 4-Way Valve. For the dynamic seal operating at working pressures to 2,000 psi Racine selected the Palmetto G-T Ring. Read why:

"We have solved our sealing problems since Palmetto G-T Ring was first designed into our valve line two years ago. This was a very definite improvement over the former seals which had given various forms of trouble. The G-T Ring provided a good seal that did not roll, twist nor extrude into the clearance spaces.

There is a minimum of friction in the Racine "Twin" Solenoid Valve. The G-T 3/16" diameter seal allows dependable delivery of solenoid power to the pilot spool each time a solenoid is energized. No noticeable change of seal friction is experienced, regardless of whether the solenoids are on occasional or high cycling circuits."

This successful application further illustrates the versatility of the G-T Ring. For your applications—static or dynamic—involving pressures to 20,000 psi, try the G-T Ring. It will give *you* definite improvement, too!

INVESTIGATE THE MANY DESIGN ADVANTAGES OF PALMETTO G-T RING PACKINGS.

CANNOT SPIRAL . . .

The Palmetto G-T Ring will not twist and turn in the groove. "T"-form prevents leakage—reduces static and dynamic friction.

CANNOT EXTRUDE . . .

Resilient "T"-section supported by non-extrusion rings on either side makes extrusion impossible. As pressure is applied non-extrusion rings are urged against wall, blocking path of extrusion.

Write for our Manual MP-200, Engineering Standards for Palmetto Molded Packings. Consult Green, Tweed's engineering department... Qualified assistance yours for the asking!

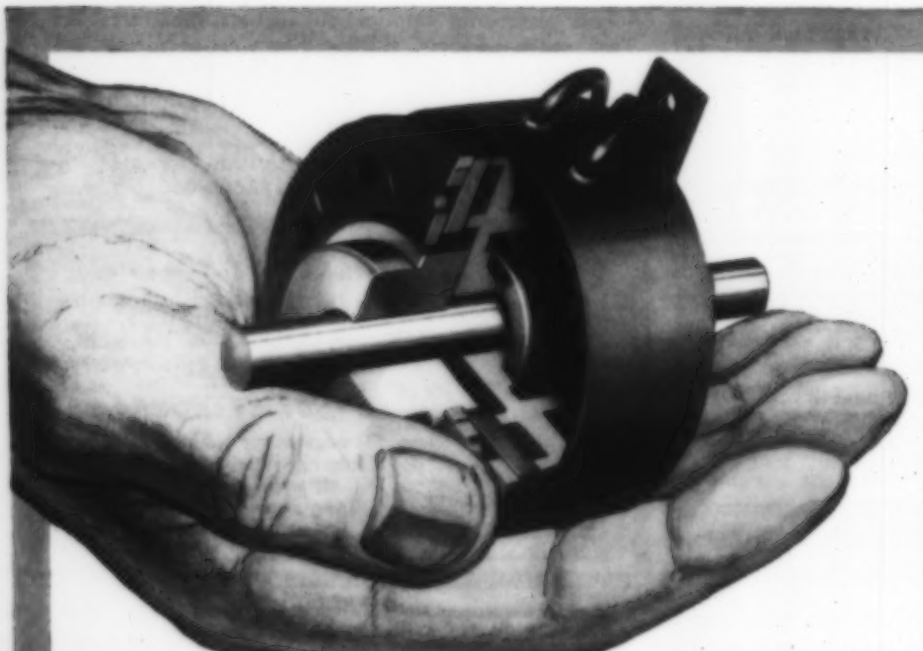
packing more performance into every application

PALMETTO Packings

GREENE, TWEED & CO. North Wales, Pa.

AUTOMATION PROBLEM
WITH

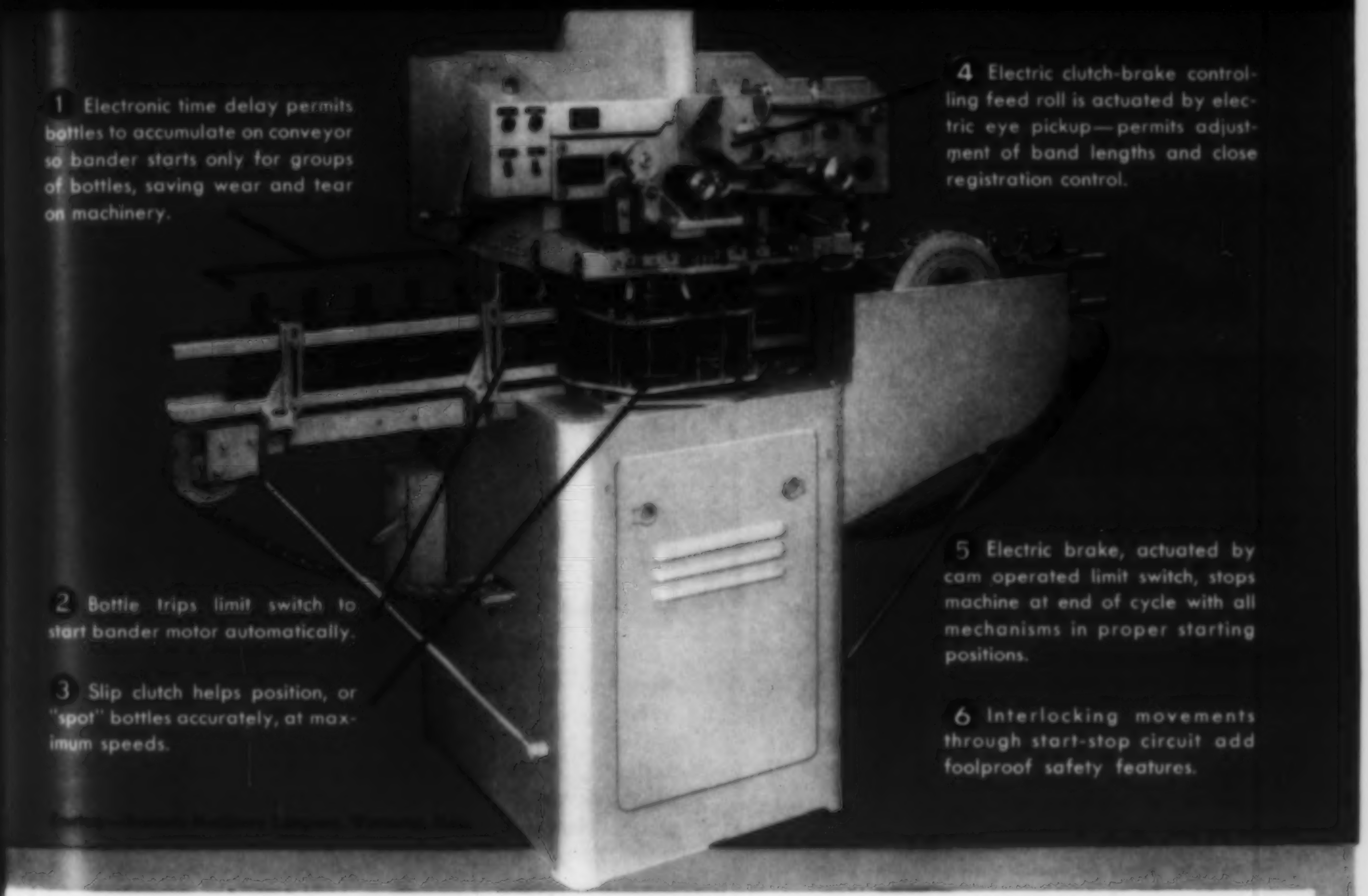
WARNER *ELECTRIC* MOTION CONTROL opens promising new opportunities for completely automatic operation of machinery and brings automation closer to your door. This bottle banding machine is a typical example—an exciting "first" in packaging—accomplished at surprising low cost. Six intermittent control functions were integrated into the electrical circuit, including: automatic starting and stopping, indexing, positioning, interlocking, and time delay (see opposite page). Warner Electric Brakes and Clutches . . . today's newest and most adroit controls for rotary drives . . . are used with photo electric cells, electronic time-delay units, and standard controls to galvanize a plurality of functions into a precisely interlocked series of split-second motions. The result is a new measure of accuracy . . . safety . . . reliability . . . durability . . . and flexibility of operation. And the bander itself now automates one of the last remaining hand operations in bottling and labeling processes.



Small, compact Warner Replaceable-Face Electric Brakes and Stationary-Field Electric Clutches are today being acclaimed by users as the most promising new type of control for low-torque machine drives (up to 240 inch lbs.). Not only do these *all-electric* units operate faster by remote automatic or push-button control, but there's a smoothness, a sureness, a new precision that puts a "Warner equipped" machine in a class all by itself. Simple voltage adjustments give you the exact torque characteristics needed for each job. And only 6 to 15 watts of d.c. are required to power the brake or clutch.

EASILY SOLVED . . .

WARNER ELECTRIC BRAKES AND CLUTCHES



1 Electronic time delay permits bottles to accumulate on conveyor so bander starts only for groups of bottles, saving wear and tear on machinery.

2 Bottle trips limit switch to start bander motor automatically.

3 Slip clutch helps position, or "spot" bottles accurately, at maximum speeds.

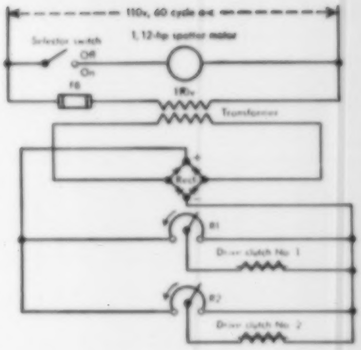
4 Electric clutch-brake controlling feed roll is actuated by electric eye pickup—permits adjustment of band lengths and close registration control.

5 Electric brake, actuated by cam operated limit switch, stops machine at end of cycle with all mechanisms in proper starting positions.

6 Interlocking movements through start-stop circuit add foolproof safety features.

Adjustable-Slippage Electric Clutch Warner Model SF-250, controls each bottle positioning roller. Torque output is easily and accurately set by means of potentiometer dials in the selenium-rectifier power pack supplying current to the clutches (see spotter drive control circuit at right). Thus, rollers can be "slipped" at any desired value of torque, permitting bottles to be spun into position quickly for high-cycle operation, yet not so fast as to force them past the backstop. Clutches slip with little wear and without overheating.

Warner Model 500 Electric Brake (upper right hand corner of photo, left) provides emergency stop for main drive.



Beat competition with

ELECTRIC BRAKES AND CLUTCHES

Warner Electric Brake & Clutch Co., Beloit, Wisconsin

Warner Electric Brake & Clutch Co.
Dept. MD, Beloit, Wisconsin

Gentlemen: Please send literature describing "SF" Electric Clutches and "RF" Electric Brakes to:

Firm Name________________________________

Individual________________________________

Address________________________________

City______________________State____________

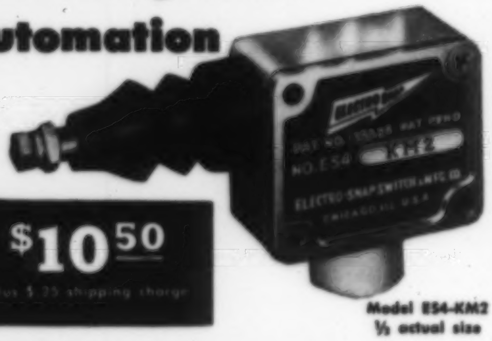
ELECTRO SNAP

ONE-WAY IMPULSE SWITCH

with exclusive advantages for automation

$10.50

plus $.25 shipping charge



Model ES4-KM2
½ actual size

ELIMINATES INTERLOCKING SWITCHES AND COMPLICATED ACTUATING DOGS

Ideal for pulsing solenoid valves on air-hydraulic controls, sequencing circuits, etc., because it allows other controls to reverse or operate the same circuit. Switch sends a short electrical impulse and then switches itself out of the circuit.

GIVES MORE DEPENDABLE CONTROL

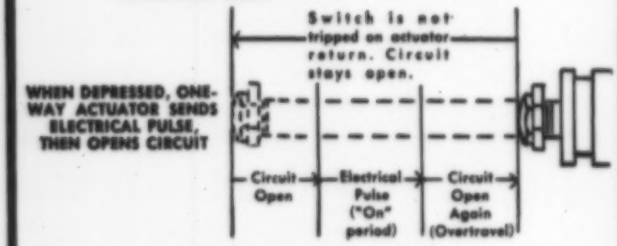
Switch replaces timers, relays, and troublesome one-way dogs to simplify circuits — cuts chances for failure. No delicate adjustments.

LOWERS COST OF CONTROL CIRCUITS

Impulse switch costs less than complicated control devices it replaces. Fewer switches are required for sequencing. Simple mounting.

SPEEDS UP AUTOMATIC OPERATION

Automatic machines can run faster because cycles can be more closely sequenced. There's no delay due to timer tolerances or extra machine motions to actuate interlock switches.


Switch is not tripped on actuator return. Circuit stays open.
WHEN DEPRESSED, ONE-WAY ACTUATOR SENDS ELECTRICAL PULSE, THEN OPENS CIRCUIT
Circuit Open
Electrical Pulse ("On" period)
Circuit Open Again (Overtravel)

SPECIFICATIONS

UL rated at 10 amps/125v AC   Movement Dif. 0.020"

Operating Force 3½ lbs.

Model No.	Overtravel	"On" Period (inches of actuator travel)
ES4-KM1	3/8"	1/16"
ES4-KM2	5/16"	1/8"
ES4-KM3	1/4"	3/16"
ES4-KM6	1/16"	3/8"

TRY ON YOUR CONTROL JOB — ORDER NOW
Send Your Standard Purchase Order
Specify Model Wanted—Discounts on Quantity Purchases

ELECTRO SNAP

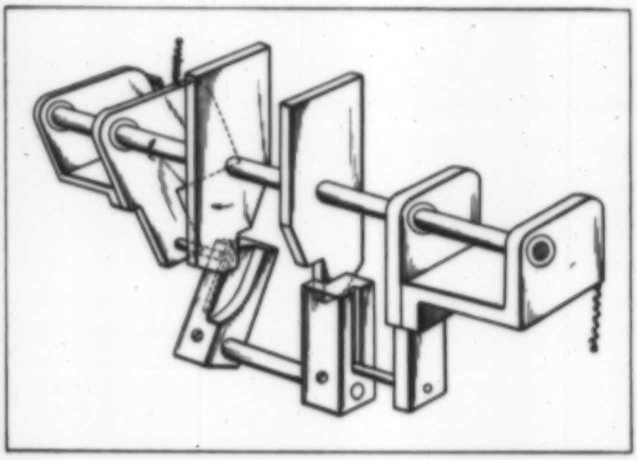
ELECTRO-SNAP SWITCH
& MFG. COMPANY
4220 West Lake Street, Chicago 24, Illinois

Noteworthy Patents

(*Continued from Page 309*)

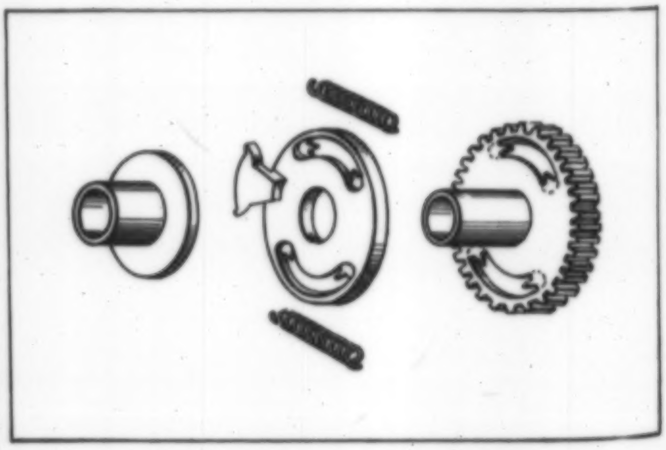
Selective Drive Output

Power may be shifted from one output shaft to the second automatically by means of locking arms associated with the side gears of a differential gear set. Revolution counters are adapted to actuate the locking arms at a predetermined number of revolutions of each output shaft. In reverse the mechanism is arranged to disengage the second shaft at the point where it was started, then reverse the first. In computer applications, the mechanism will rotate the first output shaft to the limit of its capacity, then automatically shift to rotate the second output shaft. The machine can be reset to zero by reversing the drive shaft. *Patent 2,677,286 assigned to Norden Laboratories Corp. by C. F. Schaefer.*



Cushioned Stop

Limiting the movement of a rotating part within a specified range is accomplished with a spur gear set and resilient stops. Each spur gear has an annular ring mounted with it on the same shaft and



Eastman HYDRAULIC HOSE ASSEMBLIES DELIVER MOBILE POWER *for* ALLIS-CHALMERS

"AD-40" Motor Grader

"TS-300" Motor Scraper

GLACIERS NEVER HAD IT SO EASY . . .

The millions of years required by the glaciers to scour and alter the earth diminish to mere minutes when Allis-Chalmers earth moving and grading machinery go to work. Many of these mighty machines owe much of their ease of operation and maneuverability to hydraulic power—delivered through **EASTMAN** Hydraulic Hose Assemblies.

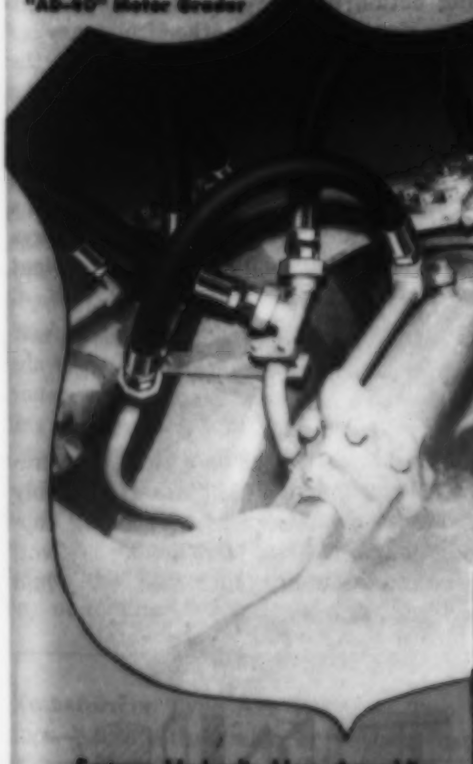
TODAY'S FARM YOUTH NEVER BORN "30 YEARS TOO SOON"

Milestones in farm mechanization are marked by Allis-Chalmers farm machinery. Pioneering in many farming innovations resulted in such exclusive firsts as the ROTO-BALER, ALL-CROP Harvester, Rear-Engine Tractor—Power Shift Wheels, SNAP-COUPLER and Hydraulic Traction Booster. Much of the operation and control of this world famous line of farm machinery is done through hydraulic power—also applied through **EASTMAN** Hydraulic Hose Assemblies.

NATURE NEVER CRUSHED ROCK LIKE THIS . . .

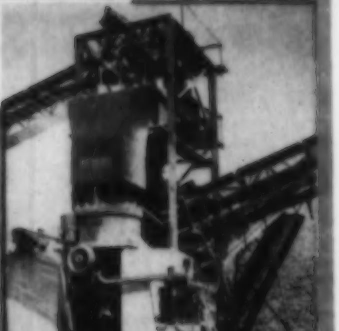
Hydraulic power on the HYDROCONE crusher affords "one man, one minute" product size control. It provides a rapid and convenient means of raising or lowering the crushing head. It permits compensation for wear and facilitates emptying the crushing chamber in case of power failure or for the quick release of uncrushable materials. Allis-Chalmers pioneered in this type of crusher—as **EASTMAN** pioneered in Hydraulic Hose Assemblies.

TURN TO EASTMAN for *your* Hydraulic Hose Assemblies, too. Whatever your requirements, always get your first recommendation from **EASTMAN** . . . *first in the field.* Exclusive designs, advanced engineering, unequalled production facilities and efficiency—mean unequalled economy, performance and constant customer satisfaction for you.



ALL-CROP Harvester

"WD-45" Tractor



HYDROCONE Crusher

Eastman Hydraulic Hose Assemblies used on steering ram of Allis-Chalmers TS-300 and TS-360 Motor Scraper. Also used on TS-300 Series to control steering, plus apron, ejector and bowl action—applying down pressure when loading equal to the weight of the scraper—38,560 lbs.]

Eastman

first in-the-field

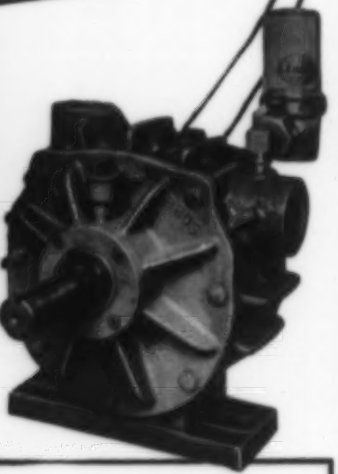
SAFEGUARDING INDUSTRY'S *Lifelines of Mobile Power*

EASTMAN MANUFACTURING CO.
Since 1914
Dept. MD-6, Manitowoc, Wisconsin

WRITE for free Catalog 101 on Eastman Hose Assemblies

THE "LIFETIME" AIR PUMPS
that take up their own wear!
No maintenance—no complaints—no shutdowns

LEIMAN
Rotary
AIR PUMPS
VACUUMS
up to 29.9" Hg.
PRESSURES up to 20 lbs.



HINGED WINGS

Patented Leiman Wings take up their own wear—maintain rated capacity for years and years.

4-WING TYPE. Vacuums to 20" Hg.; pressures to 15 lbs.; displacement to 162 cfm. Wings hinged to pistons maintain continuous sealed contact with cylinder walls by centrifugal force. Small pistons, large air chambers, greater capacity.

●

Even after 10, 15 and 20 years of continuous service, Leiman Air Pumps run extremely quiet and trouble-free—provide full, pulseless vacuum or pressure—require little or no maintenance, except lubrication. Precision-made with fewer parts, no packing, nothing to get out of order. Over half a million installed during past 60 years. Design Leiman dependability into *your* equipment. Consult our engineers on any application.

AUTOMATIC WING ADJUSTER

2-WING TYPE. Vacuums to 29.9" Hg.; pressures to 20 lbs.; displacement to 40.8 cfm. Automatic wing adjusting lever forces wear-resistant steel blades to cylinder walls, preventing sticking or binding, maintaining positive vacuum or pressure.

FREE ENGINEERING DATA

- *Application Book* showing 60 "how-to-do-it" blueprints of actual applications.
- 16-page Catalog showing construction, types, sizes, capacities, etc.

SEE OUR CATALOG IN SWEET'S FILE

LEIMAN BROS., Inc.
148 Christie Street, Newark 5, N. J.

AIR PUMPS · AIR MOTORS · SANDBLASTS · DUST COLLECTORS

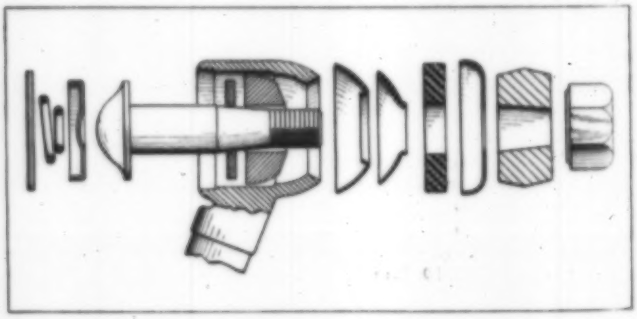
coupled to it through coil springs. Projecting stops are part of the rings. In operation, the controlled shaft is coupled directly to one of the spur gears. As the gears rotate, the projecting stops come into contact, stopping rotation. Shock is absorbed by the coil springs. By using various gear ratios of the spur gear set, a range of rotational angles may be obtained. The device was originally designed for remote control of radio apparatus. *Patent* 2,688,882 *assigned to Radio Corporation of America by M. R. Alexy.*

Magnetic Flow Control

Vibrating pistons, actuated electromagnetically, provide pumping action in a hydraulic pump design. Pumping rate is dependent upon the frequency of voltage applied to the actuating field coils and the physical construction of the coils in relation to the armatures. Rate of fluid flow to either side of a double-acting hydraulic cylinder can be controlled by varying the amount of applied voltage. A bimetallic spiral spring compensates for temperature variations so that the same flow in either direction may always be obtained for a particular voltage setting. *Patent* 2,685,838 *assigned to McGraw Electric Co. by E. J. Weinfurt.*

Joint Seal

Sealing of a movable joint, such as a tie rod or universal joint, can be accomplished with a seal assembly which includes a rubber washer and telescoping cup-shaped metal stampings. As the joint members pivot, the stampings slide to maintain a dust-free seal. Fluid sealing is maintained by compressing the rubber washer between one of the cup-shaped pieces and a dust cover. Pressure exerted by the rubber washer keeps the telescoping pieces in contact in any tilted position of the joint members. *Patent* 2,686,070 *assigned to Thompson Products Inc. by J. H. Booth.*



Copies of the patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

New Machines

Materials Handling

Electric Vibrator: Portable RC-30-LSRR electric vibrator employs the rotary weight shaft principle of developing vibration. Quiet operating, it is self-contained and has neither pulleys nor belting. The unit can be readily adapted to use on bins, hoppers and chutes by means of a quick-change female bracket. Vibrator is powered by 110 to 550-v current. Working frequency is 3600 impulses per minute, corresponding to 60 cps. A totally enclosed housing seals the unit from moisture and dust. *Cleveland Vibrator Co., Cleveland, O.*

Electric Fork Truck: Lightweight model RSAT-4 Warehouser has capacity of 4000 lb. Standard models are available in 68, 83 and 90-in. overall heights, with telescopic lifts up to 90, 120 and 134 in., respectively. Truck can be used in a 6-ft wide aisle. Use of a single lifting cylinder affords good visibility for the operator. *Yale & Towne Mfg. Co., Yale Materials Handling Div., Philadelphia, Pa.*

Bar Feeder: Model 1700 B bar feeder automatically feeds bars and tubes to such equipment as centerless grinders, polishing machines, heat treating and hardening equipment. Typical machine conveys parts ¼ to 1½ in. in diameter and 6 to 26 in. in length at any constant speed from 5 to 20 fpm from the hopper to the machine. Other models are available for conveying bars up to 60-in. long, at various rates of feed. Cycling control can be either photoelectric relay or mercury switch. *Feedall Inc., Willoughby, O.*

Metalworking

Transformer Type Arc Welders: Two welding machines, made either with or without capacitors, are dual rated at 250 amp on 30 per cent duty cycle or 200 amp on 50 per cent duty cycle for operation on a single-phase, 60-cycle, 230-v supply line. Welding current is selected by means of a rubber handwheel and rheostat knob. Control of both voltage and amperage provide desired regulation of arc characteristics for various welding jobs. The transformer has no moving parts; the core is welded, and coils are firmly anchored for quiet operation. Absence of electrical connections between power lines and welding cables assures safe operation. Double insulation and physical separations between the primary and secondary coils prevent possibility of line voltage carrying over to the welding circuit. *Hobart Brothers Co., Troy, O.*

Cabinet Lathe: Model 918 Steelway 9-in. Precision cabinet lathe is available with a production drive which permits one-operator control of multiple functions, and a variable drive for quick selection of speeds from 90 to 3750 rpm. Machine has a lever

(Continued on Page 320)

unlimited design
freedom . . . plus
vastly reduced
costs

Save as much as 67% with intricate Arwood Investment Cast Parts

It is now possible, with the Arwood investment casting process, to economically produce shapes impractical to obtain by conventional methods. Often, many assemblies can be combined into a single casting, using unmachinable alloys. Applications are virtually unlimited.

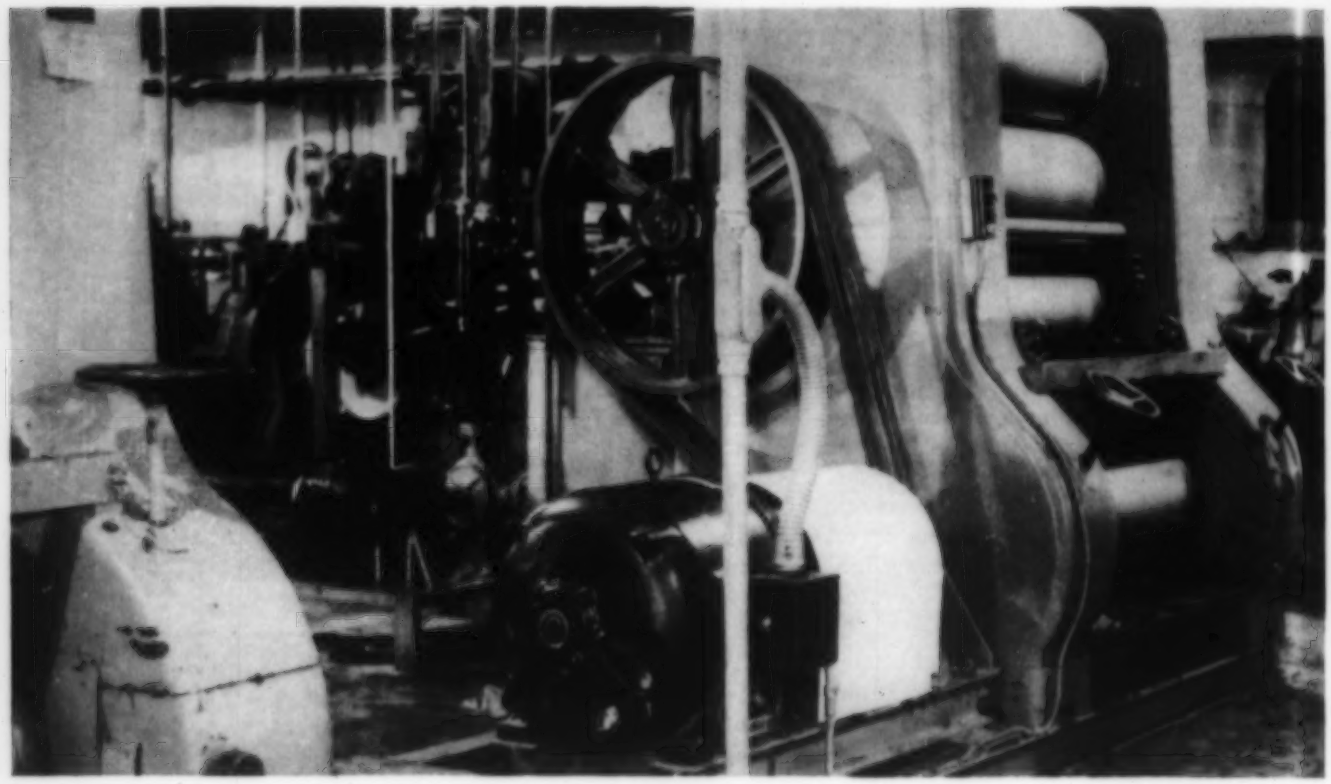
Our engineers will be pleased to go over your parts problems with you and help cut your own costs. Why not submit parts or prints to us for quotations? Consultation is free of obligation, of course.

Write for free literature describing the investment casting process.

CASE STUDY

DESIGNATION: Aircraft emergency door latch.
METAL: Stainless steel 410 (AMS 5350).
PARTS: Designed and cast as a single unit.
QUALITY CONTROL: Produced under X-ray control. Chemical and physical affidavits furnished. Test bars submitted.
ADVANTAGES: Investment casting, by eliminating all finishing operations except reaming of cast hole through pivot boss, reduced cost from over $10.00 each to approximately $3.50 each.

ARWOOD
PRECISION CASTING CORP.
78 WASHINGTON STREET • BROOKLYN 1, N. Y.
PLANTS: Brooklyn, N. Y. • Groton, Conn. • Tilton, N. H. • Los Angeles, Calif.



Let each job select

Century MOTORS ARE Performance-Rated

Why settle for *less* motor than you need? Or why pay for *more* motor than you can use? The most efficient and economical motor is one that is fitted to its application ... A Performance-Rated Century Motor.

Performance-Rating means simply that from

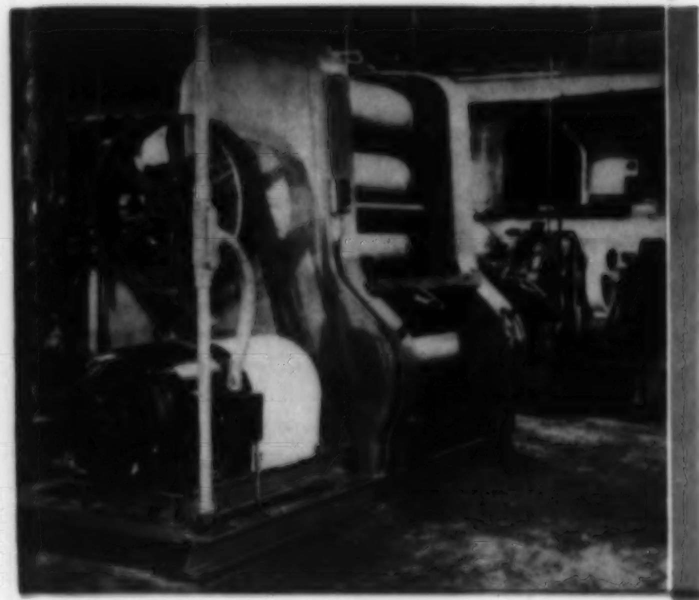
Gearmotors ... ½ to 150 H.P. ... parallel and right angle shaft ... "built-in speed to fit your need."

Selective Speed Drive Power Unit ... 1 to 150 H.P. ... a wide range of flexible speed for automatic operation and where fine increments of speed are required.

Direct Current Motors ... ½ to 300 H.P. ... a dependable teammate for Selective Speed Drives and where DC is available and its use desirable.

Squirrel Cage, Polyphase Motors ... ½ to 400 H.P. ... available in drip proof and dust proof frames, with sleeve or ball bearings, foot or flange mounting (cushion base available through 5 H.P.).

Explosion Proof Motors ... 2 to 50 H.P. ... Underwriters Laboratory listed for safe operation in hazardous atmospheres.



for example: Five-roll refiners are powered by rugged 60 H.P. Century Performance-Rated Motors, chosen to stand up under punishing loads.

Century Motors for Modern Ideas . . . AC or DC . . . Single-phase or Polyphase . . . drip proof, dust proof or explosion proof frames.

its own motor!

TO FIT YOUR SPECIFIC NEEDS

Century's complete line of motors and generators you'll get precisely the right size, speed, frame enclosure and torque characteristics you need. Century application engineers or Authorized Century Distributors are always available to help you fit a Performance-Rated Motor to your job.

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Name...*Title*..................

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Slip Ring Motors . . . 1 to 400 H.P. . . . a favorite for applications requiring unusually low starting current. Available in drip proof, splash proof and dust proof frames.

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1/8 to 400 H. P.

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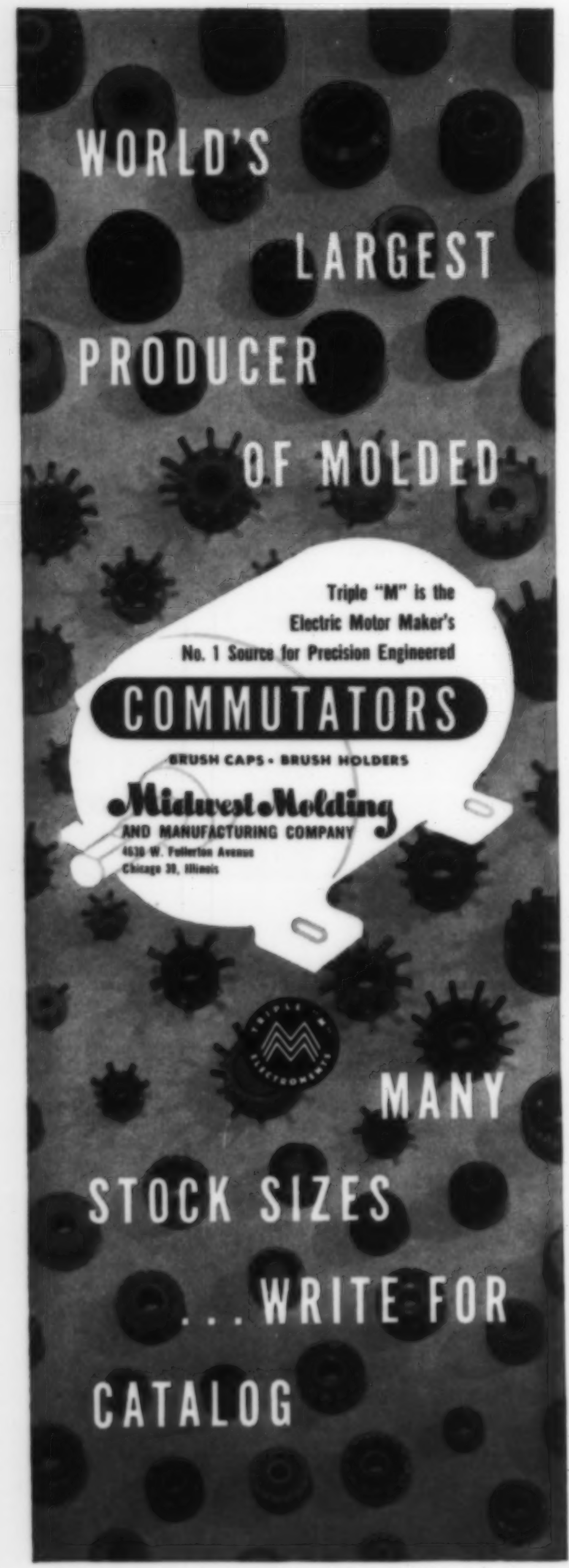
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MANY STOCK SIZES ... WRITE FOR CATALOG

New Machines

(Continued from Page 317)

chuck closer. Draw-in collets with capacity of 1⅛ in. mount directly in spindle mouth; stationary collets have no in or out motion. Step chucks accurately hold circular or irregular-shaped parts. Other features include double-bevel steelways; self-aligning slide rest; a V-belt drive which can be replaced without disturbing headstock and drive; and a headstock spindle which revolves on two superprecision preloaded ball bearings. Wide spacing on ball centers diffuses heat of end-thrust preload and distributes radial load. *Rivett Lathe & Grinder Inc., Boston, Mass.*

Ultrasonic Drill: Diatron drill cuts into hard materials such as metals, ceramics, glass and carbides. Drillheads of any geometric form drive a fluid abrasive mixture into the piece being worked; drill tip strikes several thousands of times per second to penetrate the object. Finishing or polishing are not required after drilling. The machine leaves a smooth interior surface. *Curtiss-Wright Corp., Wood-Ridge, N. J.*

Tapping Machine: Improvements in design of the Tapmaster include relocation of the lead screw to the bottom of the spindle shaft, use of an automatic dial selector to set the number of tap turns, and an electric brake to halt the tap at the end of each stroke. The machine is available in five three-spindle models, for tapping hole diameters from ⅜ to 6 in. Standard stroke length is 3 in. The machine also cuts external threads. *Prutton Corp., Cleveland, O.*

Polishing and Deburring Machine: Timesaver Smooth-O-Matic machine polishes and deburrs both ferrous and nonferrous metals such as aluminum, stainless steel and copper. Equipped with an automatic feed mechanism, it can handle all types of flat stock and sheets, single plane curved surfaces and certain shaped and tapered pieces. Work is fed over the abrasive belt at high speed and at even pressure. *Timesavers Inc., Minneapolis, Minn.*

Eight-Station Production Machine: Eight-station, center-column Rotomation machine has a 96-in. diameter index table which is indexed hydraulically through a fluid motor and gear train. Machine is adapted to close tolerance boring, drilling, tapping, facing and line reaming operations on a wide variety of parts produced at high production rates. Large size fixtures permit mounting of two medium size production parts in each fixture and processing two parts at one time at each station. Vertical heads are air-counterweighted. Clamping and unclamping of parts is pushbutton controlled by the operator. Machine is about 14 ft high and requires approximately 18 x 20 ft of floor space. *Snyder Tool & Engineering Co., Detroit, Mich.*

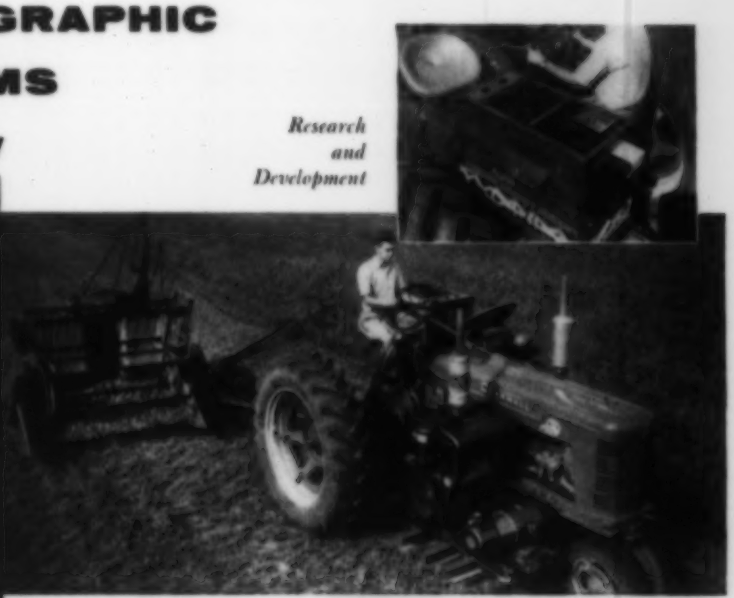
Office Equipment

Photocopy Machine: New Dial-A-Matic Auto-Stat has an illuminated dial which is set to match the type of original to be copied. Machine automatically produces dry copies of written, printed, drawn or photographed material in 30 seconds' time. Paper up to

. . . from field-testing harvesters to checking jet starter performance . . .

SANBORN OSCILLOGRAPHIC RECORDING SYSTEMS prove their versatility

Research and Development



FOR INTERNATIONAL HARVESTER'S ENGINEERING TEST AND DEVELOPMENT DEPT.

A specially housed and shock-mounted Sanborn 2-channel recorder provides dynamic strain measurement data on a field forage harvesting machine, during actual field use. In the photographs, rotor shaft torque and RPM are being recorded, one of several uses International Harvester has found for the Sanborn System in field testing their farming equipment.

Production Testing

AT ARCH GEAR WORKS, QUINCY, MASS. . . .

A record of tooth regularity of various types of precision gears is obtained on a single-channel Sanborn Model 141 System, used in conjunction with a special gear checking instrument devised by Arch Gear Works. The equipment permits visual spot checking of gears, helps maintain a high rate of acceptability and provides a permanent record of tests often required by customers.

Research and Production Testing

AT G. E.'S AIRCRAFT GAS TURBINE DIV. . . .

Engineers record performance data such as temperatures, pressure, RPM and starting time of jet engine starters, using a modified Sanborn Model 67 System. Six channels of information are recorded in this four-channel unit, equipped with three DC amplifiers, one Triplexer, a four-channel DC Converter, two-channel zero suppression network and two modified strain gage amplifiers. The data also provides G. E. engineers with an indication of the performance of all production units.

These typical applications indicate the scope of usefulness of standard and modified Sanborn Recording Systems. Wherever accurate, permanent, graphic registration of electrical phenomena in the 0-100 cps range is required, the *versatility* and *flexibility* of Sanborn one-, two-, four-, six- and eight-channel systems will prove invaluable. A wide variety of readily interchangeable, plug-in preamplifiers enable *one* basic system to meet *many* recording requirements. Standard instrument features include inkless recording in true rectangular co-ordinates, high torque galvanometer movement, time and code marking, and a choice of nine chart speeds.

CATALOG AND TECHNICAL DATA AVAILABLE ON REQUEST

SANBORN COMPANY

INDUSTRIAL DIVISION
CAMBRIDGE 39, MASS.

"MONOBALL"
Self-Aligning
Bearings

ROD END TYPES
PLAIN TYPES

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All World Rights Reserved

CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Moly Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Moly Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. Address Dept. MD55.

SOUTHWEST PRODUCTS CO.
DUARTE, CALIFORNIA

15 in. wide and any length can be used. Self-adjusting developer rollers take any weight paper from tissue to heavy card stock without manual adjustment. Filling and emptying of the developer tank is accomplished with a plastic squeeze bottle and tube. Size of machine is 24 x 9 x 5 in. wide. *American Photcopy Equipment Co., Chicago, Ill.*

Noiseless Typewriter: Light pressure on keys of new Remington noiseless typewriter activates a weight which completes the pressing of the type onto paper, thus providing a uniform impression. Finger-contoured keys are cushioned to eliminate impact. Machine has provision for instant setting of identical margins, as well as a simplified type bar. Cover is easily removable for cleaning and servicing of the machine, and the removable platen facilitates necessary changes for stenciling or typing on cards. Typewriter is offered with new executive type styles. *Remington Rand Inc., New York, N. Y.*

Accounting Machine: Cardatype accounting machine is composed of an electric typewriter, an auxiliary numerical keyboard, and equipment for reading punched cards and automatically controlling the entire operation according to a preset program. Three more connected, unattended typewriters can be installed beside the machine for the production of related forms such as shipping tags or stock selection tickets. An automatic computing unit is also provided, and card punching or tape punching units and a second auxiliary keyboard can be added. Requiring just one operator, the machine is said to be particularly adaptable to small business operations. Most steps in a billing operation, for example, can be done automatically by the machine. *International Business Machines Corp., New York, N. Y.*

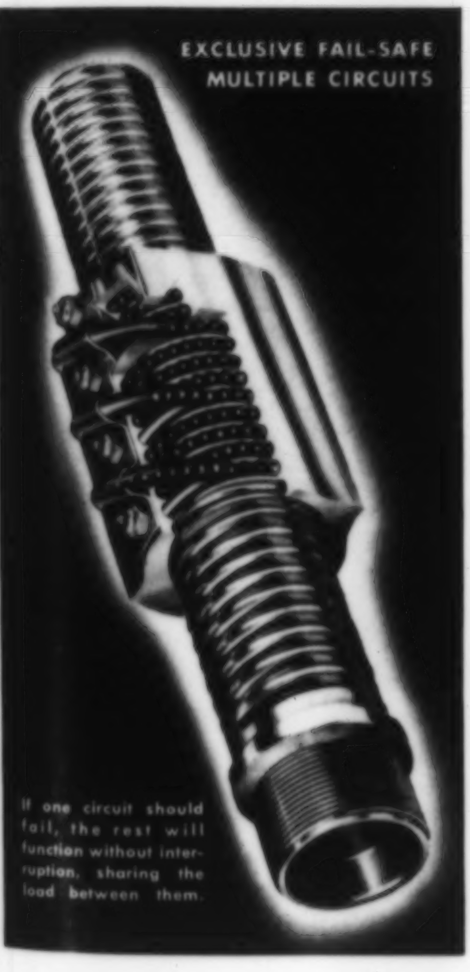
Testing and Inspection

Contour Projector: Portable, bench type contour projector, Kodak model 8 is adaptable for either horizontal or vertical projection gaging. An erect, right-reading image is produced in either position. Device is designed for checking small parts. The parts can be staged in holding fixtures for horizontal projection or placed on a glass stage, with the machine turned on end, for vertical projection. Lenses incorporated in the projector yield a bright image, permitting use anywhere in a plant. Six magnifications ranging from 10 to 100X are provided, and all lenses are quickly interchangeable. *Eastman Kodak Co., Rochester, N. Y.*

Vibration Tester: Electrodynamic shaker system for vibration testing of assemblies and components is capable of developing 100 lb peak force output in the 40 to 3000 cps frequency range and displacement amplitudes in excess of 0.4-in. peak-to-peak in the 5 to 40 cps range. Lightweight armature increases the useful portion of the total force output. Flexure system provides positive linear armature motion. Built-in calibrated velocity signal generator monitors the amplitude of vibratory motion. Controls, indicators and power for operation of the system are contained in a single unit, housed in a standard relay rack cabinet. *Calidyne Co., Winchester, Mass.*

Now—

UNPRECEDENTED BENEFITS FOR ALL YOUR ACTUATOR APPLICATIONS WITH THE SAGINAW BALL/BEARING SCREW



EXCLUSIVE FAIL-SAFE MULTIPLE CIRCUITS

If one circuit should fail, the rest will function without interruption, sharing the load between them.

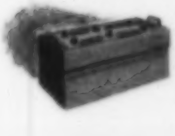
SPACE/WEIGHT SAVINGS PERMIT MORE PAYLOAD

Compared to either Acme screw or hydraulic actuators, the *Safety b/b Screw* saves significant weight and space by permitting the use of smaller motors and gear boxes; eliminating pumps, accumulators, piping, etc.

DEPENDABLE OPERATION DESPITE LACK OF LUBE

Because the *Safety b/b Screw* is inherently so friction-free (operating at 90% to 95% efficiency), it will function with only a small loss of efficiency *even if lubrication fails or cannot originally be provided.*

FAR LESS DRAIN ON ELECTRICAL SYSTEM



By requiring only 1/3 as much torque as a conventional Acme screw for the same amount of lineal output, the *Safety b/b Screw* allows the use of much smaller motors which save a substantial amount of power.

POSITIVE POSITIONING AND SYNCHRONIZATION

Unlike some other types of actuators, the *Safety b/b Screw* permits precision control within thousandths of an inch, plus perfect synchronization of two or more movements—a tremendous aircraft advantage.

RELIABLE PERFORMANCE AT EXTREME TEMPERATURES

Exhaustive laboratory tests prove that the *Safety b/b Screw* operates dependably at both extremely low and high temperatures, ranging from—75° F to + 175° F, and up to + 900° F with special consideration.

GREATLY DECREASED COMBAT VULNERABILITY

By eliminating highly vulnerable hydraulic lines, accumulators, etc., the *Safety b/b Screw* makes military aircraft actuation far more dependable. It also reduces maintenance, due to decreased dirt sensitivity.

UNITS HAVE BEEN PRODUCED FROM 1½ IN. TO 39½ FT.

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Saginaw Steering Gear Div.,
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Dept. 6H, Saginaw, Michigan

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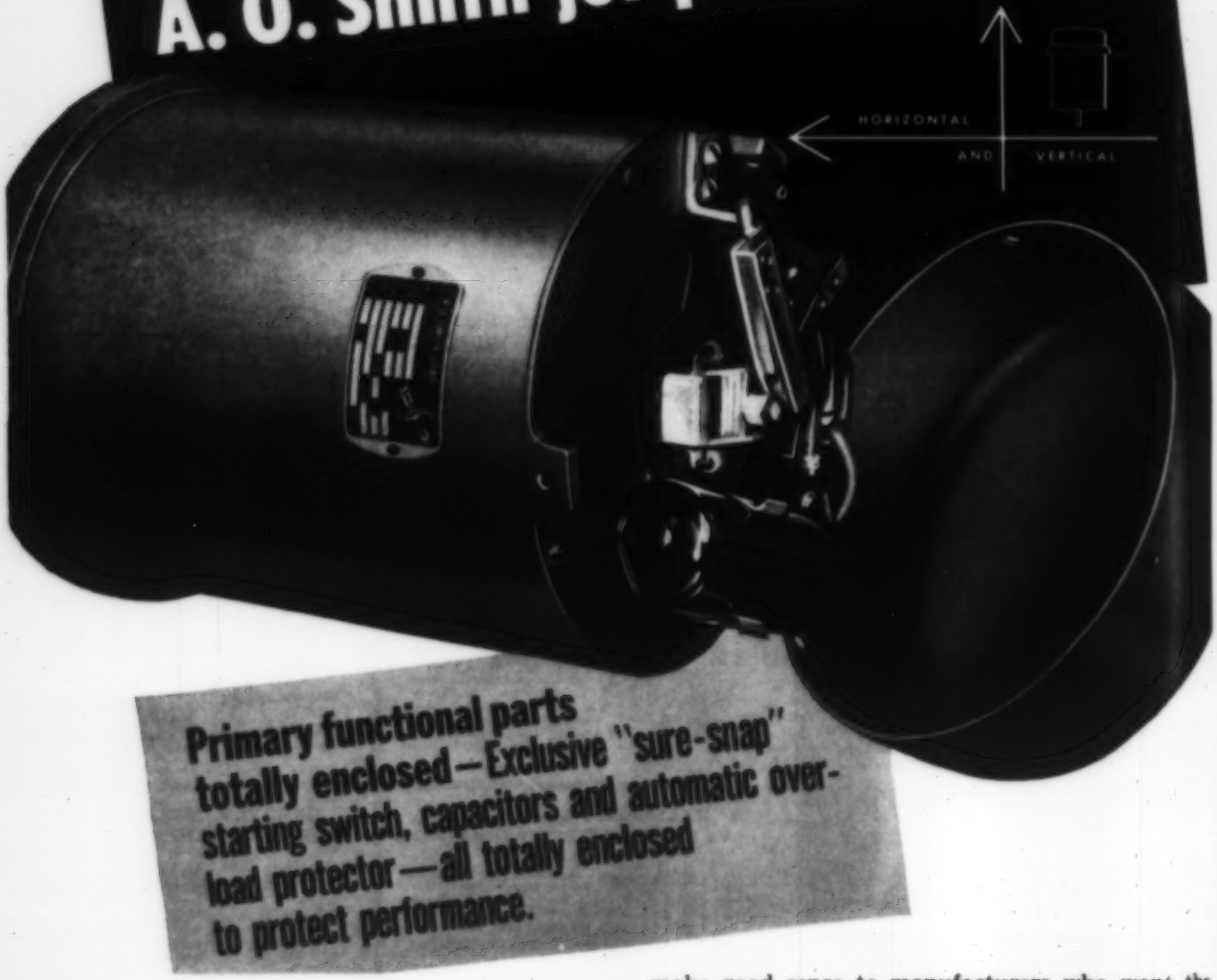
Safety ball/bearing Screw by Saginaw

Now! a new line of A. O. Smith jet pump motors



Primary functional parts totally enclosed—Exclusive "sure-snap" starting switch, capacitors and automatic overload protector—all totally enclosed to protect performance.

Pioneer producer of a full jet pump motor line—backed by millions of units in service—A. O. Smith offers you great new models with application-engineered advantages. Your choice of single and three-phase design — ⅓ through 2 hp.

CANOPY PROTECTION FOR VITAL COMPONENTS

Totally enclosed grouping locks out dirt, dust and other foreign matter. Vital parts stay clean for more years of dependable service.

POSITIVE VENTILATION

Controlled cooling further promotes long life and low maintenance. Generous intake and discharge louvers, large, shaft-mounted fan, ample air-space behind stator core assure adequate and uniform cooling of windings and rotating parts.

READY FOR OTHER APPLICATIONS

These new motors pack dramatic versatility. They make good sense to manufacturers who want the advantages of totally enclosed design at a cost far lower than conventional models of this type.

Get all the facts about these great new performers as well as the other motors made by A. O. Smith. Ask the representative who calls on you . . . or write A. O. Smith Corporation, Electric Motor Division, P. O. Box 170, Dayton, Ohio.

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SIX SIZES

- 1/2 to 30 hp
- Single or double reduction
- Wide output speed range—420 to 10 rpm

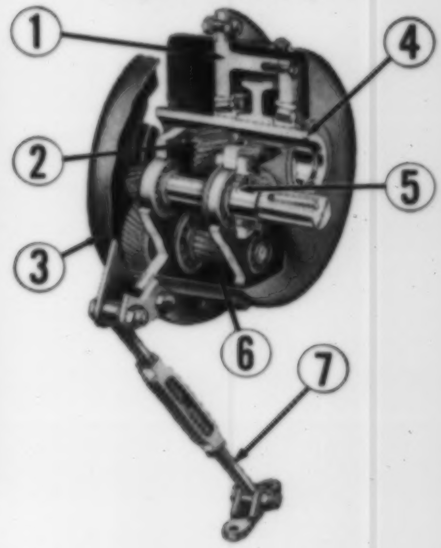
FALK
ALL-STEEL
Shaft Mounted Drives—
simple-compact-rugged-efficient

Created specifically for the vast number of applications demanding a sturdy and compact speed-reducing unit for direct mounting on the driven shaft, the new Falk all-steel Shaft Mounted Drive is built to give long service life at substantial savings of space, time, power and maintenance costs!

This efficient helical-gear drive, latest in the unmatched list of Falk precision-gearing achievements is an ingenious modification of the time-tested Falk Motoreducer design which has held, for more than 20 years, recognized leadership in this branch of highest-quality power transmission . . . It complements and completes the world-famous Falk line of reduction units covering the entire range of industrial applications.

Investigate the Falk all-steel Shaft Mounted Drive. Write to Department 247 for engineering bulletin, including selection and dimension details.

These famous FALK "In-built" factors *mean long life and dependability...*



1 **All-steel Frame,** with more than double the rigidity of iron, supports all rotating elements.

2 **Precision Helical Gears,** designed and machined by Falk, rated to AGMA standards.

3 **Pressed Steel Housings,** whose sole function is to keep oil in, dirt out; easily removed for gear inspection without dismounting unit.

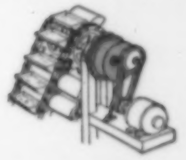
4 **Through Hollow Shaft** with counter bore provides for easiest installation or removal from driven machine shaft extensions.

5 **Backstop** can be furnished with the unit or added later for positive prevention of reverse rotation.

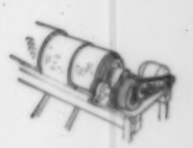
6 **Positive Lubrication,** continuous direct dip of revolving elements at all speeds.

7 **Tie Rod** and turnbuckle serve as anchor and facilitate V-belt or chain adjustment.

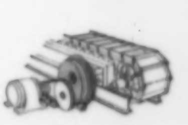
A FEW TYPICAL APPLICATIONS



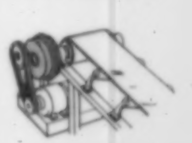
BUCKET ELEVATOR



SAND CLASSIFIER



APRON FEEDER



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THE FALK CORPORATION, Milwaukee 8, Wisconsin

MANUFACTURERS OF

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- Speed Reducers
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- High Speed Drives
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- Single Helical Gears
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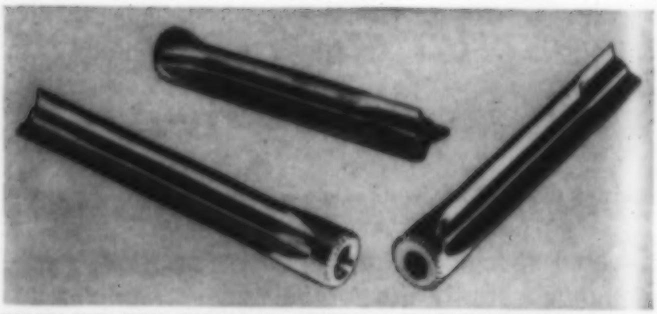
FALK

. . . a good name in industry

WIDE ENDURO BELT
...keeps scratches off bandages

CORROSION RESISTANCE IN TUBULAR FORM. Republic's Steel and Tubes Division turns out miles of ENDURO Stainless Steel Tubing for the process industries and for mechanical applications. Republic ELECTRUNITE Stainless Steel Tubing and Pipe offer the identical high mechanical and corrosion-resisting properties demonstrated in sheet form by the Reynolon belt. Call Steel and Tubes for application assistance on all your fluid handling and tubing problems.



WHAT'S EVEN MORE CORROSION-RESISTANT? REPUBLIC TITANIUM. Titanium surpasses even stainless steel in resistance to many severe forms of corrosion. Yet, it weighs only 56% as much as alloy steel. Here, Republic Titanium supplies corrosion-resistance and lighter weight to parts designed to knit human bones. Republic Titanium and Titanium alloys now are available for civilian applications. Republic has the experience to help you use them best. Write us.

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- ☐ Republic ENDURO® Stainless Steel
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NO CONTAMINATION—NO SPOILAGE. Republic Steel offers a full range of barrels, drums and pails in a variety of metals and finishes to protect your chemical, food and other products. Choose from ENDURO Stainless Steel, hot dipped galvanized steel, hot dipped tinned steel, mill galvanized sheet steel, hot rolled open hearth steel, plain or lacquer lined. Choice of gages to meet all handling and shipping requirements. Many styles in sizes up to 55 gallons. Contact Republic.

Steel coating machines for production of [illegible] plastic film are equipped with [illegible] wide ENDURO Stainless Steel belts. Only Republic can supply this extreme width. Photo courtesy Reynolds Metals Company, Plastics [illegible]

This wide, polished ENDURO Stainless Steel belt carries Reynolon plastic coatings in process. One such type makes the peel-off backing for those handy packaged small bandages you use.

The ENDURO surface provides a high luster finish! Since the slightest scratch would be "mirrored" or duplicated in the finished product, the quality of the stainless steel surface determines the quality of the plastic coating. Here, ENDURO keeps scratches off bandages!

Note that the belt is supported only by top rollers. That allows both sides to carry the plastic material . . . speeds production. It also means that the belt must have great tensile strength. ENDURO supplies that strength. In this case, tension on the belt runs as high as 90 tons.

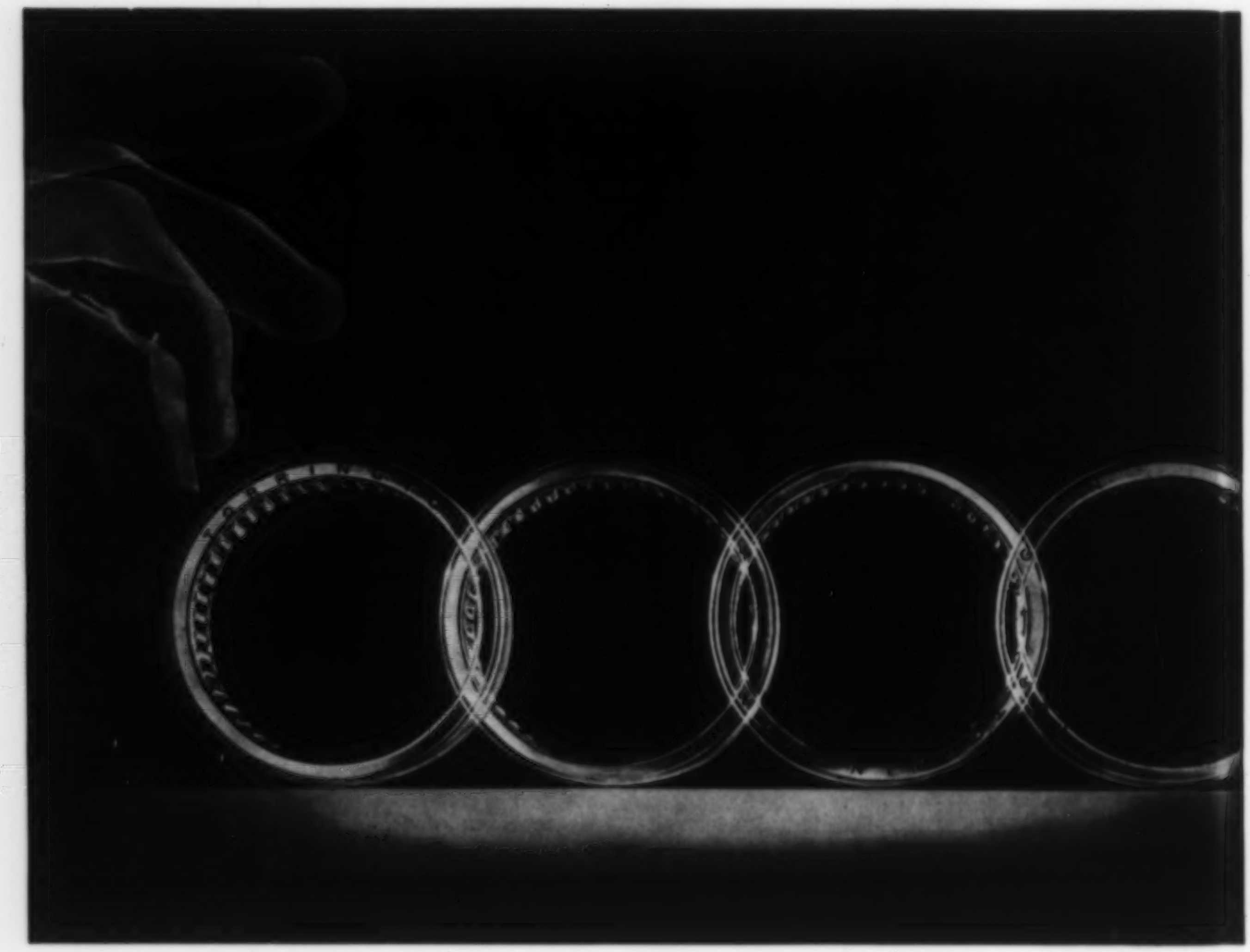
What's more, this belt must be heat-resistant. In process, material passes through 600° ovens. And, many of the plastics processed are in hydrous or acidic solutions. So, the belt must resist rust and corrosion. ENDURO does just that.

Four of these sixty-inch wide belts help produce Reynolon plastic film. Even at this extreme width, the belts must stay flat. "Crowned" metal could snap like an oil can and damage the plastic.

Republic metallurgists worked closely with Reynolds Metals Company, Plastics Division, to develop this unusual equipment. If you have process or product problems involving heat, corrosion, surface finish or strength, ENDURO Stainless Steel quite likely is your answer. Republic metallurgists will help you apply it most profitably. Write Republic.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products



"It takes less push . . .
to start a **TORRINGTON NEEDLE BEARING"**

The Torrington Needle Bearing has a low coefficient of friction—both in starting and in running. Therein lies a boon for designers and manufacturers.

Unlike a plain bearing which has a fairly high starting coefficient of friction—the Needle Bearing needs no more push to "get it going" than to "keep it going."

Nor are the frictional characteristics of the Needle Bearing dependent upon maintaining a continuous oil film as is a plain bearing. This all adds up to inexpensive and simpler designs, smaller drive motors and dependability.

For twenty years our engineering department has helped designers and manufacturers throughout industry to adapt the unique characteristics of the Needle Bearing to their products. Let us help you make the Needle Bearing "standard equipment" in yours.

THE TORRINGTON COMPANY
Torrington, Conn. • South Bend 21, Ind.

These features make the **TORRINGTON NEEDLE BEARING** *unique*

- low coefficient of starting and running friction
- full complement of rollers
- unequalled radial load capacity
- low unit cost
- long service life
- compactness and light weight
- runs directly on hardened shafts
- permits use of larger and stiffer shafts

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TORRINGTON *NEEDLE* BEARINGS

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers

There's no sense in even *trying* to be an expert in *all* phases of manufacturing today. And there's no need to. For your specialized motor problems, you can turn to Leland's competent sales and design engineers – experts you can "add to your staff" *for the asking*.

With years of practical experience in serving manufacturers, and a finger-tip knowledge of Leland designs and applications, our representatives can often give you an immediate recommendation. They may confer with our capable staff of skilled design engineers. Often, the design engineer will wish to discuss the problem directly with you, to obtain all the pertinent data needed for a thoroughly practicable solution.

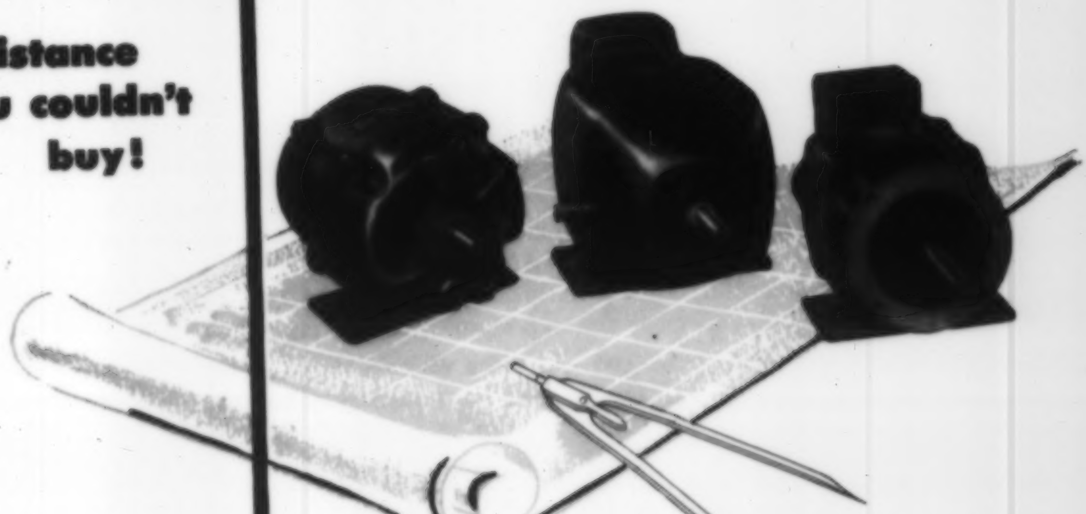
For more than 30 years, Leland has been a leader in the design and manufacture of unusual motor items. And though it has been a constant challenge, sometimes a seemingly impossible one, the reward has been the regularity with which Leland has come up with the answer.

Today, the complete line of Leland motors, standard or special, reflects the wealth of design know-how acquired through developing units for so many widely diversified applications.

Try Leland on *your* motor requirements, from ⅙ to 5 hp. Profit from Leland's experience and the in-built quality of its standard motors. Or consult our representatives in principal cities about your *special* motor problems. Add a real specialist to your staff.

Yours for the asking

Design assistance you couldn't buy!



Another AMF Product

LELAND MOTORS

THE LELAND ELECTRIC COMPANY
Division of American Machine & Foundry Company
Dayton 1, Ohio

Speed Nut
TYPICAL USES

This one SPEED NUT for either screw provides new savings!

If you use "A" and "Z" sheet metal screws in your product assemblies, here's good news for everyone from your design and production engineers to stock room clerks.

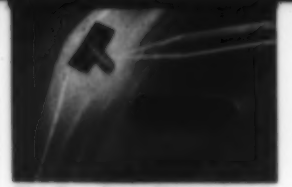
C7000 Flat Type Speed Nuts work equally well on both "A" and "Z" sheet metal screws—only one type of Speed Nut brand fastener to purchase, stock and handle. You reduce inventories, eliminate parts mixing. And you can also lower unit costs through larger quantity purchases.

One Speed Nut replaces three parts . . . lock washer, threaded nut and spanner washer. Yet it offers an attachment that is permanently tight until you want to loosen it!

Ask your Tinnerman representative for samples of the new dual-service C7000 Flat Type Speed Nut . . . it's the modern way to save time and money, and avoid headaches!

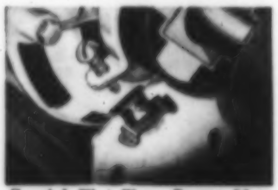
TINNERMAN PRODUCTS, INC. • BOX 6688, DEPT. 12, CLEVELAND 1, OHIO
Canada: Dominion Fasteners, Limited, Hamilton, Ontario. *Great Britain:* Simmonds Aerocessories, Limited, Treforest, Wales. *France:* Aerocessoires Simmonds, S. A., 7 rue Henri Barbusse, Levallois (Seine). *Germany:* Hans Sickinger GmbH "MECANO", Lemgo-i-Lippe.

TINNERMAN Speed Nuts®
FASTEST THING IN FASTENINGS



Flat Type Speed Nuts cut costs of attaching auto radio speaker to baffle.

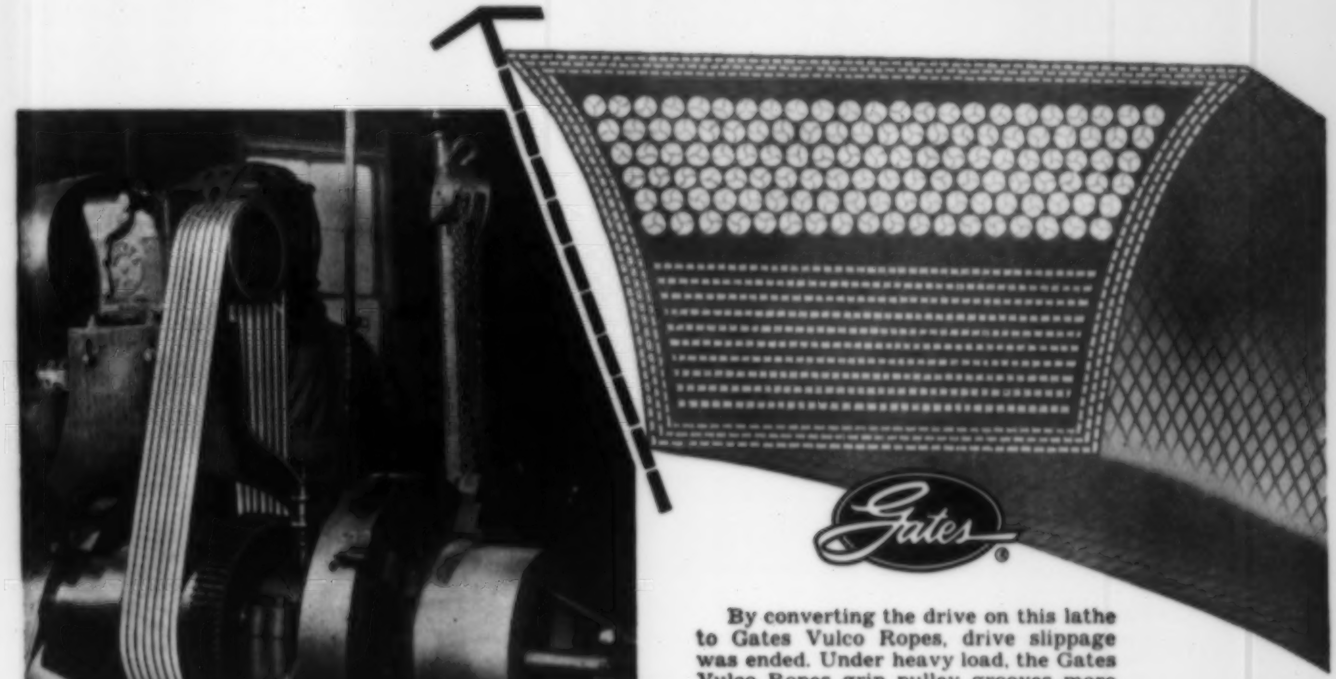
Air-conditioner control-panel assembly costs cut 40% with help of Flat Type Speed Nuts.



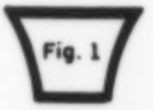
Special Flat Type Speed Nut reduced assembly time 87% on washer motor mount bracket.

More than 8000 shapes and sizes

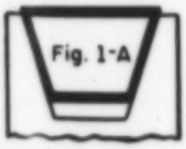
"Secret" of *lower* belt costs is concave sides



By converting the drive on this lathe to Gates Vulco Ropes, drive slippage was ended. Under heavy load, the Gates Vulco Ropes grip pulley grooves more firmly and pull harder. Management states that now that the lathe can take heavier cuts, they are getting twice as much production as before.



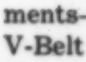
Plants that keep track of costs on drives know this: they get longer wear at *lower cost per year of service* when they specify Gates Vulco Ropes—the V-Belts with *concave sides.*



Here's WHY concave sides keep belt costs down:

When the Gates belt is bent around the sheave, the *precisely engineered* concave sides (Fig. 1) fill out and become straight (Fig. 1-A). Thus the belt makes uniform contact with the sides of the pulley.

This full, uniform contact assures *even distribution of wear.* Naturally, *even wear* means *longer wear.* And longer wear cuts belt replacement costs...reduces down time...contributes to profits.



Prove to yourself the value of concave sides

Bend a straight-sided belt (Fig. 2) and feel the sides *bulge out* around the bend. You see immediately that the bulging sides prevent an even fit in the pulley groove (Fig. 2-A). Uneven contact causes faster wear...increases belt replacement costs.

Reduce costs and down time for belt replacements—specify Gates Vulco Rope Drives—the V-Belt with *concave sides* (U.S. Patent 1813698). The Gates Rubber Co., Denver, Colorado—*World's Largest Maker of V-Belts.*

Gates Engineering Offices and Distributor Stocks are located in all industrial centers of the United States and Canada, and in 70 other countries throughout the world.

TPA 46-A

GATES VULCO ROPE DRIVES

what's your problem?

$X + 32 - R^2 \div 126 + 7$
$+ P + 2^2 - 76 \times \pi RT - 10_2$
$\times 14\,2 + 7 \cdot 48 \div 21 \times 34_3$
$\div 12 \times M^7 = ?$

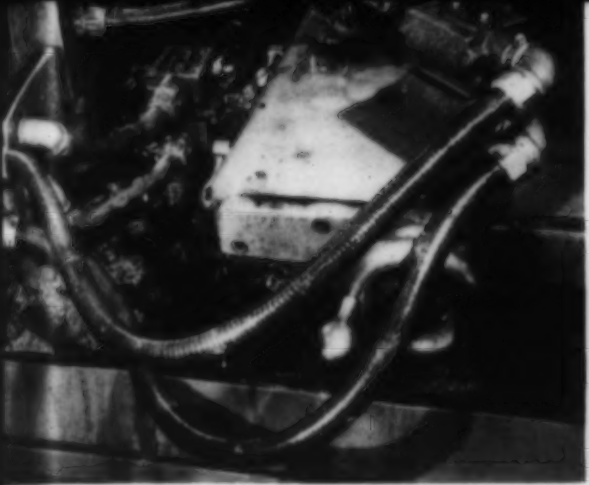
Parts? Finishes? Components? Materials?
Maybe one of the advertisements in this issue of MACHINE DESIGN has the answer to your current mental whiplash.

Or maybe the answer is suggested but you want to find out for sure. Why not spend a few seconds right now and get it over with?

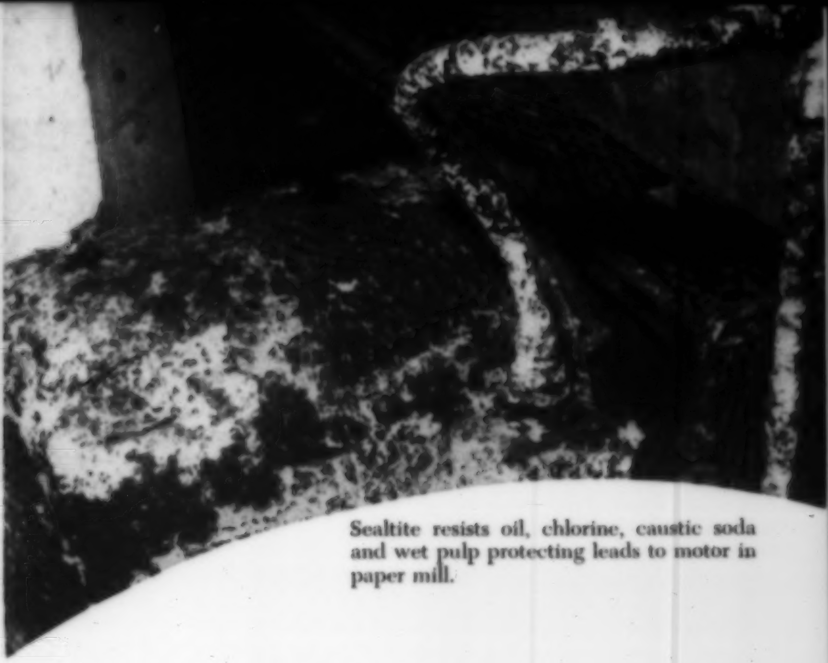
Fill out one of the advertising inquiry cards (always *yellow*) and shoot it to us. No letters or postage necessary.

We'll send your inquiry immediately to the advertiser and he will then reply directly to you.

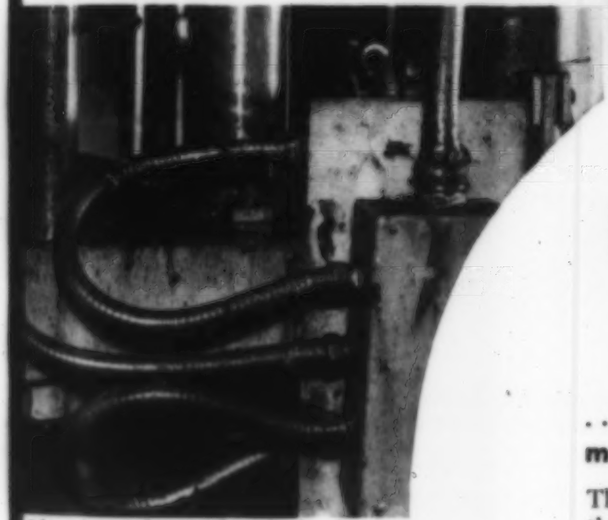
USE THE YELLOW CARDS ON PAGE 33



Production grinder moves back and forth, continuously flexing Sealtite and spewing metal dust, oil and coolant over it.



Sealtite resists oil, chlorine, caustic soda and wet pulp protecting leads to motor in paper mill.



Oil, grease and water from hydraulic press can't hurt wiring protected by Sealtite. Type E.F., used here, is extra flexible to make small-diameter U-bends, hug machine tool contours.

TYPE U.A. Sealtite flexible, liquid-tight conduit. Tough polyvinyl jacket over interlocked, zinc-plated steel strip. Copper conductor wound spirally in the space between each convolution on the inside of the conduit.

Give SEALTITE the dirtiest jobs around the plant

. . . this liquid-tight, flexible conduit protects wiring against moisture . . . oil . . . chemicals . . . weather . . . mechanical damage.

There are good reasons why you see Sealtite* protecting wiring on these dirty, critical jobs. It won't corrode. Nothing gets through its tough, extruded polyvinyl outer jacket. And day in, day out, Sealtite stands up under continuous flexing . . . gives maximum protection wherever wiring must connect moving parts . . . absorb vibration . . . follow contours . . . house wires with maximum protection. More, you save the installation time it takes to bend and fit rigid conduit.

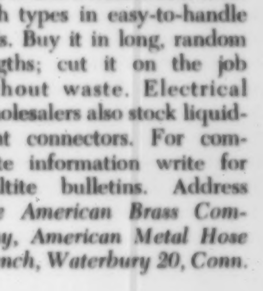
TYPE U.A. is approved by Underwriters' Laboratories for service in wet spots. Copper conductor wound spirally inside conduit for positive ground.

TYPE E.F.† is extra flexible. Ideal for machine tool applications. Meets J.I.C. standards. Now available in machine tool standard light gray at no extra cost from mill stocks.

55160

*Trade mark

†Patent Applied For

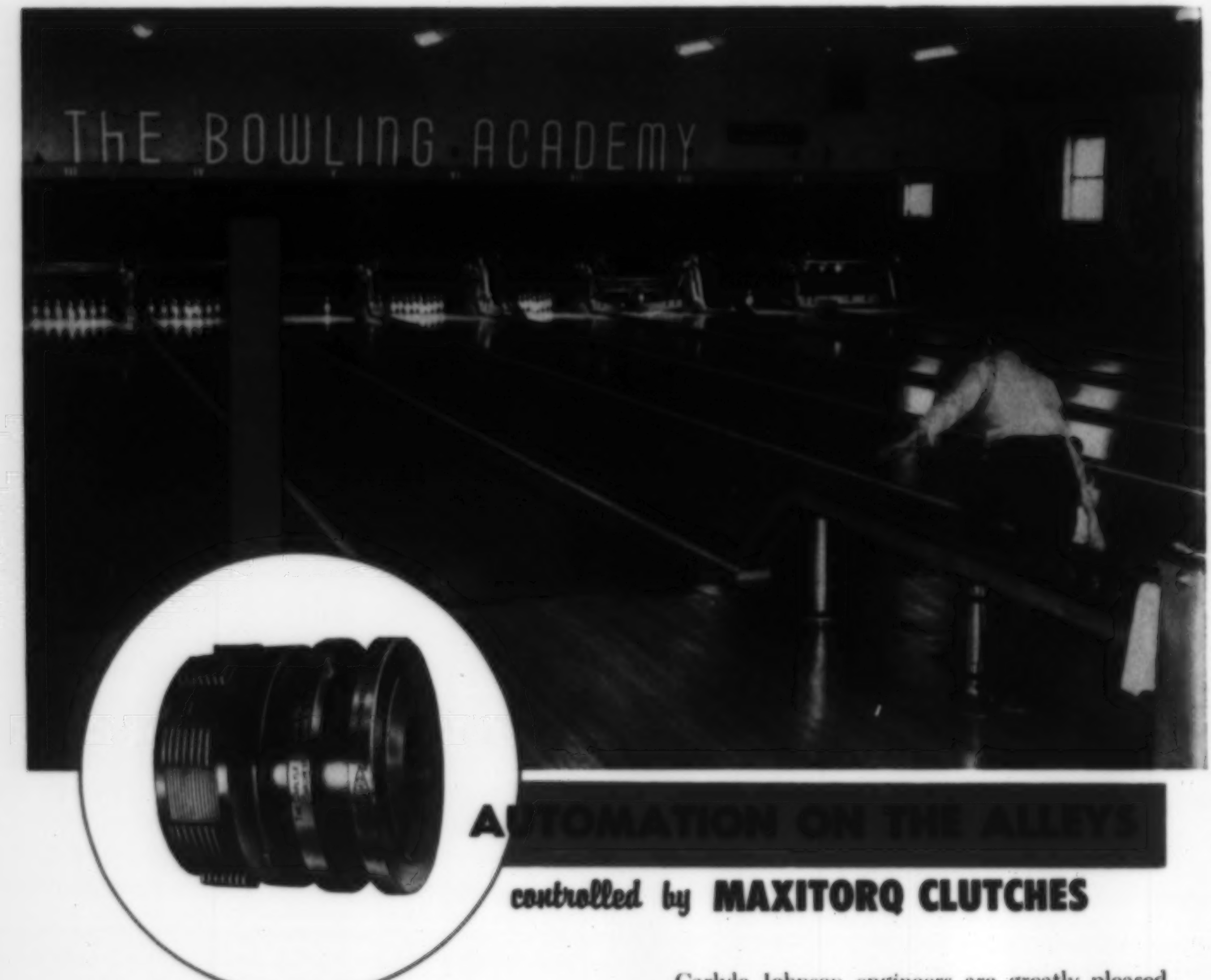


ELECTRICAL WHOLESALERS stock both types in easy-to-handle coils. Buy it in long, random lengths; cut it on the job without waste. Electrical Wholesalers also stock liquid-tight connectors. For complete information write for Sealtite bulletins. Address *The American Brass Company, American Metal Hose Branch, Waterbury 20, Conn.*

SEALTITE

FLEXIBLE,
LIQUID-TIGHT CONDUIT

an **ANACONDA**® product



AUTOMATION ON THE ALLEYS

controlled by MAXITORQ CLUTCHES

The photograph above shows the first installation by Sherman Enterprises, Inc., Worcester, Mass., of their automatic PINSETTER.

The pin boys have been replaced by this ingenious mechanism, a part of which is accurately controlled by Maxitorq floating disc clutches. Two solenoid-operated No. 22 clutches control (1) the elevator pick-up and setting of pins to correct position and (2) operate the distributor conveyor which carries forward the sorted pins. Alleys No. 2 and 10 show the automatic pin sweepers that clear the alleys for re-setting. Bowling balls are also automatically returned.

Carlyle Johnson engineers are greatly pleased that Maxitorq clutches have been selected for this important improvement in bowling alley operation. We have worked with the builders for several years to perfect this automatic control . . . and we will gladly cooperate with you in any power distribution problems that require accurate and dependable service.

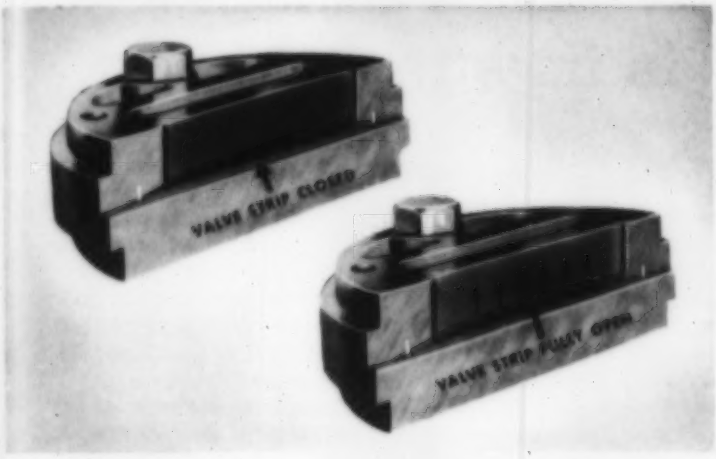
Write for our latest catalog containing drawings, specifications and complete information on Maxitorq Multiple Disc Clutches, Automatic Overload Release Clutches, Johnson Single Disc Clutches and the Maxitorq Disc-Pac.

Send for Catalog No. MD-6.

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

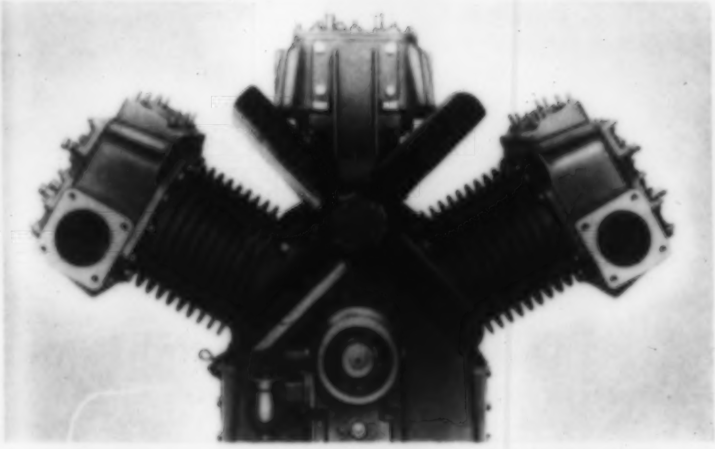
WHAT'S YOUR C.Q.*?

*COMPRESSOR QUOTIENT



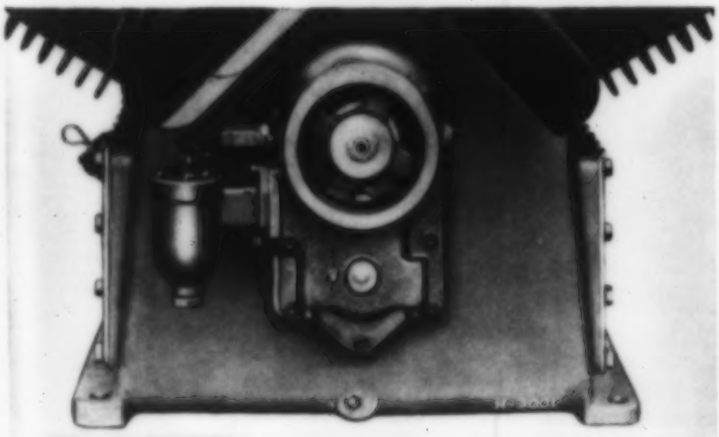
What's the lightest-acting air compressor valve made?

No doubt about this one — it's Worthington's exclusive Feather* Valve. Responsive as a feather to air flow, it can open, release air and close in one-hundredth of a second—with no back-leaking and efficiency losses. You can get more information about the Feather Valve by writing for Bulletin L-675 S12.



How can you get effective air cooling of air compressors?

Fan-cooling of isolated cylinders is the answer. In Worthington Radial and Balanced Angle air compressors, cooling air flows completely around the isolated cylinders. And the high-capacity fan blows air directly over upper parts of cylinders and cylinder heads — where heat is greatest. Our Bulletin H-630-B1 tells you more about Worthington Radial air-cooled air compressors.



What's the modern way to lubricate an air compressor?

The right answer is force-feed lubrication—with continuous full-flow oil filtration. And that's exactly what you get in Worthington Radial Air Compressors (and *only* Worthington, by the way). Result: less bearing wear, less oil pumping, longer cylinder life and lower lubricating oil cost. One twist of the handle cleans the Cuno filter without stopping flow. Read Bulletin H-630-B1 for more facts.

PC.5.3

**Reg. U.S. Pat. Off.*

Write today for bulletins to Worthington Corporation,
Section PC.5.3, Harrison, N.J.

WORTHINGTON

SPECIFY THESE WORTHINGTON STANDARD PRODUCTS ON YOUR EQUIPMENT

Air Compressors • Pumps • Multi-V-Drives • Allspeed Drives

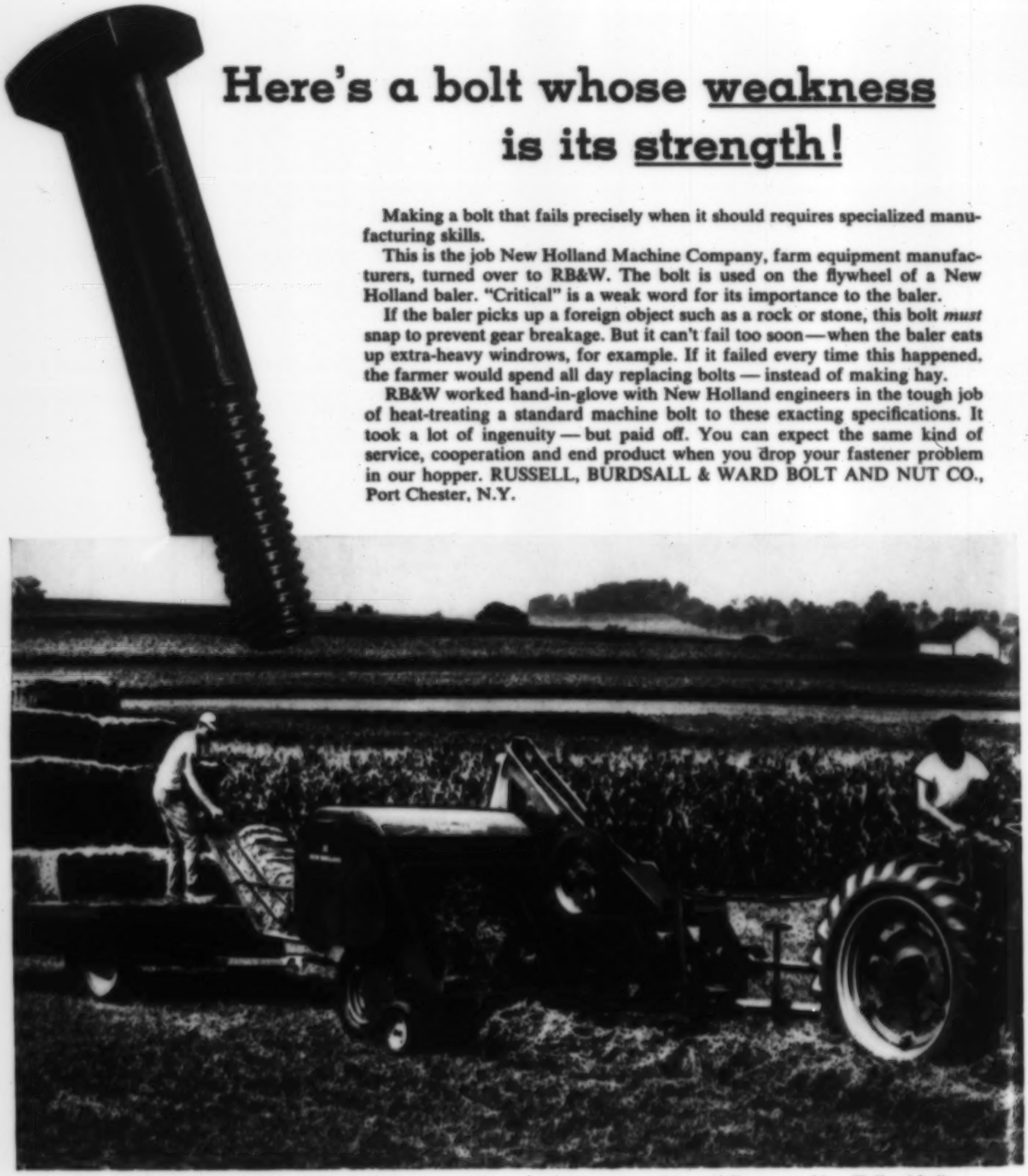
Here's a bolt whose weakness is its strength!

Making a bolt that fails precisely when it should requires specialized manufacturing skills.

This is the job New Holland Machine Company, farm equipment manufacturers, turned over to RB&W. The bolt is used on the flywheel of a New Holland baler. "Critical" is a weak word for its importance to the baler.

If the baler picks up a foreign object such as a rock or stone, this bolt *must* snap to prevent gear breakage. But it can't fail too soon—when the baler eats up extra-heavy windrows, for example. If it failed every time this happened, the farmer would spend all day replacing bolts — instead of making hay.

RB&W worked hand-in-glove with New Holland engineers in the tough job of heat-treating a standard machine bolt to these exacting specifications. It took a lot of ingenuity — but paid off. You can expect the same kind of service, cooperation and end product when you drop your fastener problem in our hopper. RUSSELL, BURDSALL & WARD BOLT AND NUT CO., Port Chester, N.Y.

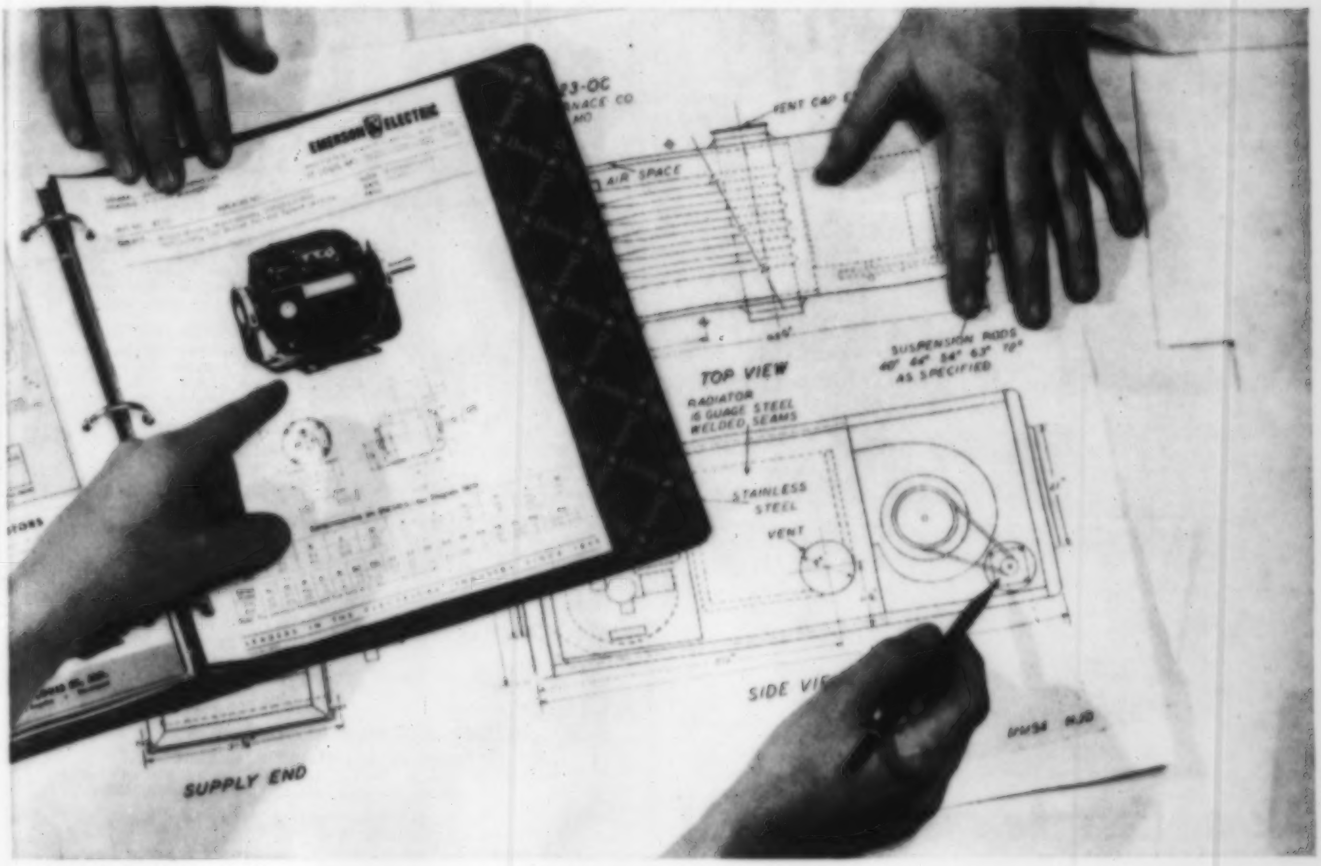


UP TO TWELVE TONS OF HAY AN HOUR is the capacity of New Holland's Super 77 power take-off baler. With every minute vital in harvesting, farmers can't take chances on machinery failure — so New Holland built rugged parts into the Super 77, gave it extra-large capacity for fast, reliable operation.

RB&W **RUSSELL, BURDSALL & WARD**

110 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG

Plants at: PORT CHESTER, N.Y.; CORAOPOLIS, PA.; ROCK FALLS, ILL.; LOS ANGELES, CALIF. *Additional sales offices at:* ARDMORE (PHILA.), PA.; PITTSBURGH; DETROIT; CHICAGO; DALLAS; SAN FRANCISCO. *Sales agents at:* NEW ORLEANS, DENVER, SEATTLE. *Distributors from coast to coast.*



AN EMERSON-ELECTRIC MOTOR-DRIVE SPECIALIST PROVIDES "ON-THE-SPOT" HELP FOR YOU

The biggest plus value any appliance or equipment manufacturer can get from Emerson-Electric is the benefit of 65 years of specialized experience in power drives.

Emerson-Electric specialists will start at the beginning, or idea stage, of your problem—will stay with it through every phase of development and application—will work closely with your engineers on any improvement program you have in mind . . . Their services are available *right now*—at Emerson-Electric you don't have to stand in line and wait your turn, because every customer is a most valuable asset.

Profit by Emerson-Electric's years of experience and the combined ability of its motor specialists. They know motors AND their application. They can save you time and money.

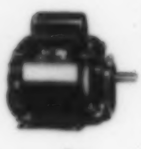
Emerson-Electric supplies motors for appliances and equipment principally in these classifications: Oil Burner Blowers • Unit Heaters • Water Circulators • Air Conditioning • Washers Driers • Ironers • Garbage Disposers Refrigerators • Freezers • Water Pumps • Air Compressors

For Oil Burners

For Pumps

Hermetic Motor Parts

For Laundry Equipment


For Blowers

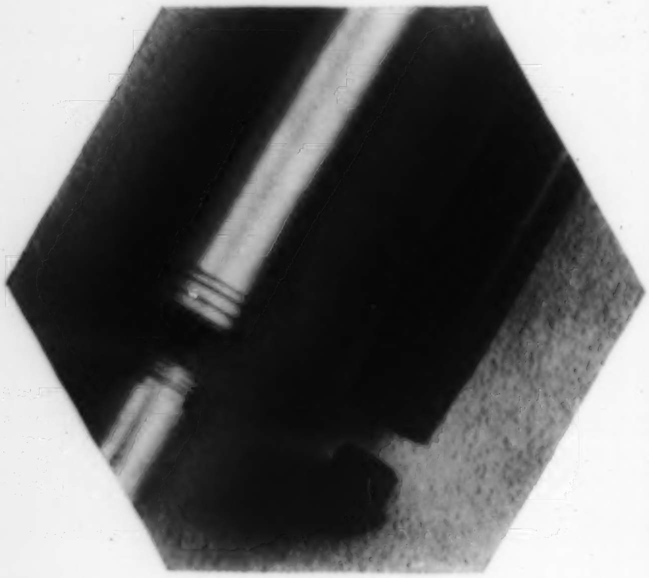
Write THE EMERSON ELECTRIC MFG. CO., ST. LOUIS 21, MO., for bulletins listed below.

☐ M 4010-A Capacitor-Start
☐ M 4010-D Fan Duty
☐ M 4010-B Split-Phase
☐ M 4010-E Oil Burner
☐ M 4010-C Integral
☐ M 4010-F Jet Pump
☐ M 4010-G Blower

Emerson-Electric
of St. Louis • Since 1890

BRANCHES: New York 17, N. Y., 420 Lexington Ave. • Chicago 23, Ill., 1623 S. Pulaski Road • Syracuse, N. Y., 209 Oakley Drive
Detroit 7, Mich., 1375 E. Jefferson Ave. • Los Angeles 42, Calif., 5415 York Blvd. • Davenport, Iowa, 617 Brady St.
Cincinnati 11, Ohio, 2917 Ratterman Ave.

There is a right way to finish this aluminum part



Alcoa offers the answers here...

On many screw machine jobs there are operations which can be done in different ways, but, there is usually just one "best" way. To supplement your own experience, Alcoa offers users of Alcoa® Aluminum Screw Machine Stock a complete technical packet containing: calculators for feeds, speeds and properties; an engineering handbook on machining aluminum; a booklet of corrected tool diameter tables; case histories of savings; a conversion chart for alloy designations. The complete packet is free for the asking. Just fill out and mail this coupon today.

ALUMINUM COMPANY OF AMERICA
873-F Alcoa Building, Pittsburgh 19, Pa.

Gentlemen:
Please send your technical packet on aluminum screw machine stock to:

Name________ Title________

Company________

Address________

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

VULCAN
ELECTRIC HEATING UNITS

Vulcan Ring Heaters

The same standard construction as Vulcan cartridge and strip heaters. Coil of highest grade resistance wire is supported in and insulated from sheath by refractories of proven quality.

Easily installed by clamping against the surface of hot plates, pots, defrosters, vulcanizers, moulds, dies, water heaters, etc.

Rust-resisting sheath for temperatures to 750° F.

Stainless steel sheath for temperatures to 1200° F.

6 standard sizes

Special sizes available

VULCAN ELECTRIC COMPANY, Danvers 6, Mass.

EXPERIENCED SPECIALISTS IN ELECTRIC HEAT
Makers of Vulcan Electric Soldering Tools, Electric Solder Pots, Electric Branding Irons, Electric Heating Units

See 8 page Vulcan catalog in Sweet's Product Design File for 1955.

DEPENDABLE
ECONOMICAL
Elliott

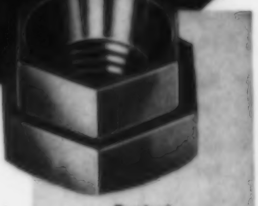
FLEXIBLE SHAFT drives this baled hay pickup safely. It eliminates many parts in assembly, drives the machine from the tractor's power take off. It's easily detached, saves the price of a separate power unit.

Elliott flexible shaft fits your design plans with the same versatility. You'll find it in applications from wind tunnels to special heavy industrial machinery and farm machinery. It's reliable, too: 12 out of 15 concrete machinery manufacturers specify Elliott flexible shaft.

When you design your next machine, call on Elliott. Trained engineers can show you how to simplify assembly, save components and build a more compact machine with Elliott flexible shafts.

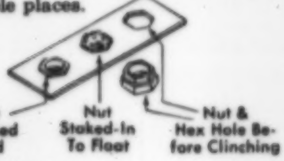
Elliott Write for Bulletin 221 TODAY
MANUFACTURING CO.
217 Prospect Street, Binghamton, N. Y.

use these
GRIPCO CLINCH NUTS
with the exclusive
hex on hex
feature



for "fixed" fastenings for "hard-to-reach" or blind assemblies. They wear longer, hold tighter, give greater customer satisfaction.

See how leading appliance manufacturers get lower cost fasteners into inaccessible places.



Typical Applications
Automatic Washer for leg leveling and crating on all appliances
Tractor Seats
Power Lawn Mowers
Automobile Frames

Gripco Clinch Nuts can be either clinched solid for a rigid application or staked in with a six point staking punch to give a floating effect. This floating effect takes care of misalignment and makes the application of the bolt easier. Gripco clinch nuts can be clinched or staked with stationary or portable hydraulic or air equipment. Details on request. Write for samples and data sheet.

113

GRIP NUT COMPANY
310-W S. Michigan Avenue, Chicago 4, Illinois

Design for Low Control Cost...

ARENS "Seven Standards" may help you save money.

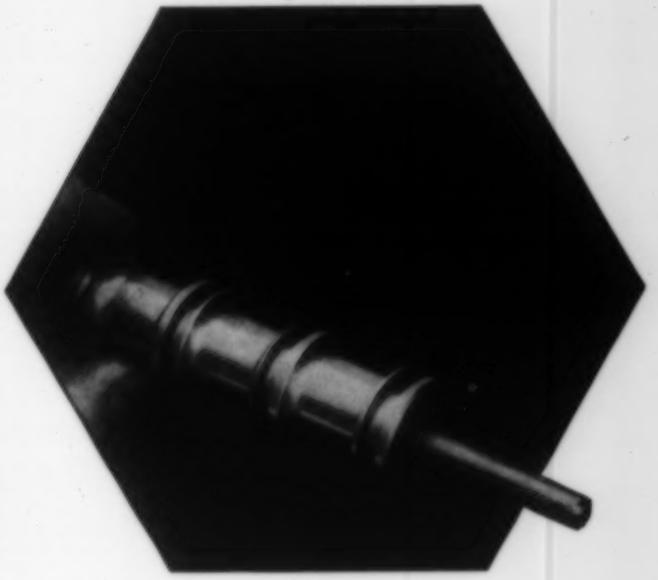
ARENS
PUSH-PULL CONTROLS

Low in price, easy to install, there are seven standard Arens designs to meet light, medium and heavy load requirements. They are available with a variety of control heads, casings, and end fittings. Special controls can also be designed to meet specific requirements. Design with Arens Controls in mind . . . and save.

Write for Catalog

ARENS CONTROLS, INC.
2009 Greenleaf Street, Evanston, Illinois

There is a right way to deep drill this aluminum part



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ALUMINUM COMPANY OF AMERICA
873-T Alcoa Building, Pittsburgh 19, Pa.

Gentlemen:
Please send your technical packet on aluminum screw machine stock to:

Name________________ Title________________

Company________________

Address________________

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

Here are MODERN WAYS

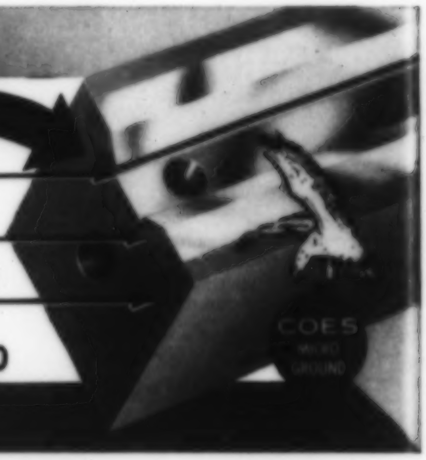
MACHINE WAYS TO YOUR SPECIFICATION of hardened-and-ground tool steel inseparably welded to tough, machineable steel backings.

PRECISION GROUND • INTERCHANGEABLE •
WEAR AND SHOCK RESISTANT • REPLACEABLE.

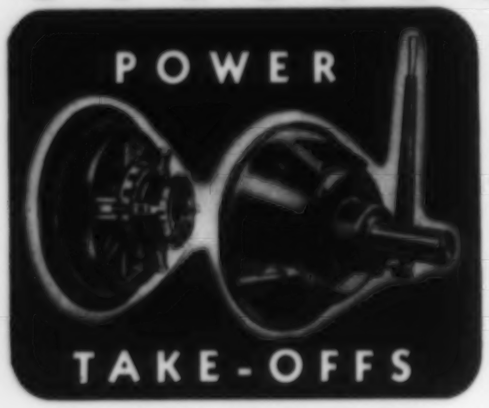
Many other uses, wherever rolling or sliding wear is concentrated. Get the latest literature, or send sketches of your requirements to:

- Tool Steel for HARDNESS
- Forge Welded for STRENGTH
- Machineable Steel for TOUGHNESS

COES KNIFE COMPANY, Worcester, Mass.- Est. 1830



ROCKFORD



A SIZE AND TYPE FOR EVERY USE

- SELF CONTAINED UNIT
- WIDE RANGE OF SIZES
- CONSERVATIVE RATING
- ROLLER BEARINGS
- EASY ADJUSTMENT
- ACCURATE BALANCE
- S.A.E. DIMENSIONS

• ROCKFORD POWER TAKE-OFFS are available in standard sizes ranging from 125 foot pounds to 2100 foot pounds torque. Clutch sizes range from 6½ to 18 in. double plate. These complete, self-contained units are suitable for heavy-duty gear-tooth application to current industrial gasoline and diesel engines.

Send for This Handy Bulletin

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD CLUTCH DIVISION BORG-WARNER
311 Catherine Street, Rockford, Illinois, U.S.A.

CLUTCHES

BOOST 100 PSI AIR PRESSURE TO 30,000 PSI FLUID PRESSURE

for... $289.50
(F.O.B. Gardena, Calif.)

Continuous-acting, air-driven. Various ratios give maximum fluid pressures of 100 to 30,000 psi. Size: 8¼" wide x 9⅝" deep.

Eight standard models. Special models for lower or higher pressures. Applicable wherever low-volume output at high pressures is the requirement, such as static testing, powering presses for forming, shearing, clamping, etc. Thousands in use. Complete power packages also available. Send for Bulletins.

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Engineering Corporation
• 1144 WEST 135th STREET, GARDENA, CALIFORNIA •

Design
Manual

"MECHANICAL ADJUSTABLE-SPEED DRIVES"

Parts I & II
by Leo F. Spector

COMPLETE REPRINTS NOW AVAILABLE! $1.00 PER COPY

→ USE ORDER FORM PAGE 198

THE NEW

"SR" MOTOR BASES

WITH THE
SMOOTH-SLIDING, TUBULAR CARRIAGE
AND
SQUARE STEEL RAILS
MADE IN THREE TYPES
FOR ALL NEMA FRAMES BOTH OLD AND NEW
From No. 56 Through No. 326-U

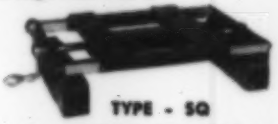
TYPE - ST

FOR PERFECT CONTROL OF BELT TENSION

Proper tension adjustment is made while operating under load merely by turning a screw.

A completely enclosed grease-packed spring provides the tension, absorbs those shock loads and compensates for a considerable amount of belt stretch before readjustment is necessary.

Peak output is sustained and maintenance is reduced to a negligible quantity.



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for MOTORS EQUIPPED with VARIABLE-PITCH PULLEYS

The free-sliding carriage and grease-packed screw provide 'finger-tip' control at the crank. For this reason the "SR" is preferable for those applications where frequent and rapid changes in speed are required, or where the drive is at a considerable angle from the plane of the Base.

Type SQT is for those drives having fixed diameter pulleys where the center distance is frequently changed.

All Types can be Mounted in Any Position

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Increases capacity in 1/3 less space!

In this 100 hp compressor drive, one Browning Poly-V 20-groove "M" drive 8" wide replaces multi-V drive of 8 "D" belts 12" wide. Ups capacity 12% in 1/3 less space. Permits shorter shaft, reduces bearing pressure. Costs less, too.

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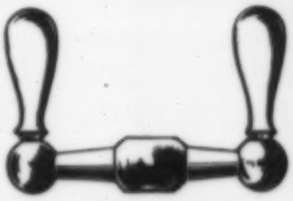
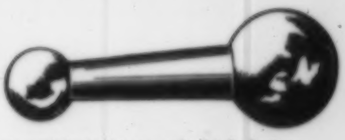


COMPOUND RESTS WITH TWO HANDLES



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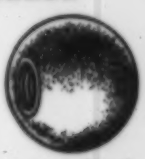

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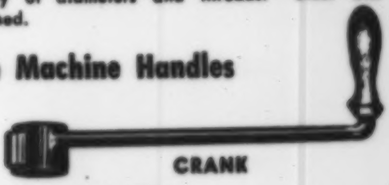

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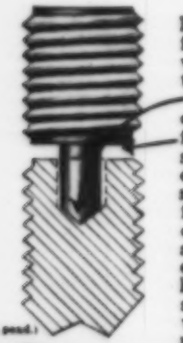

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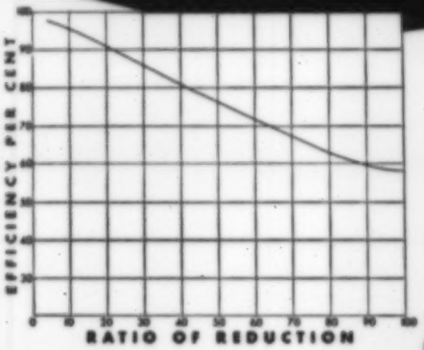

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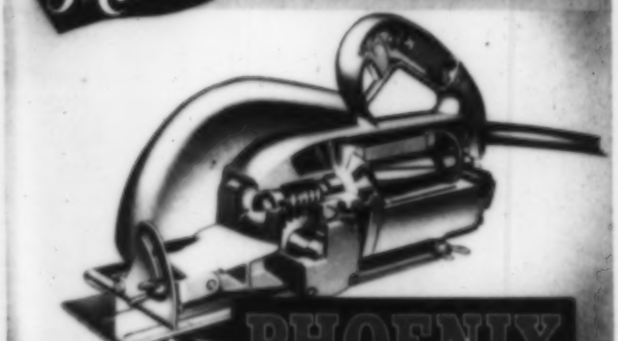

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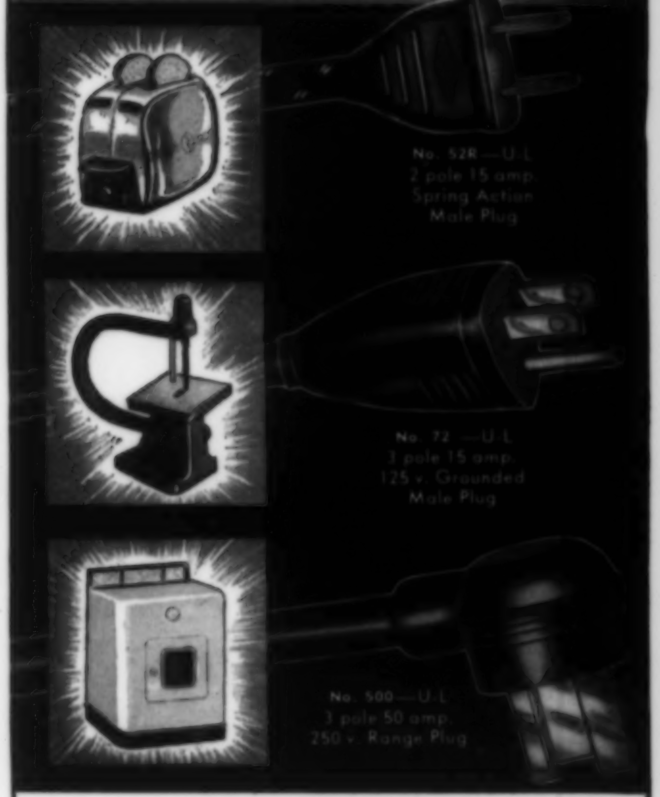

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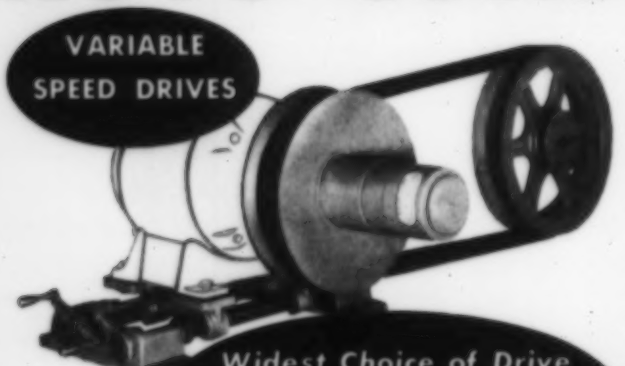
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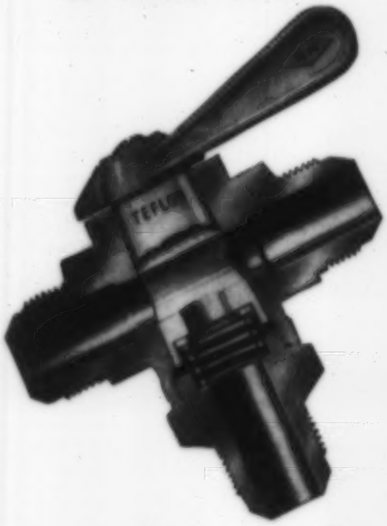

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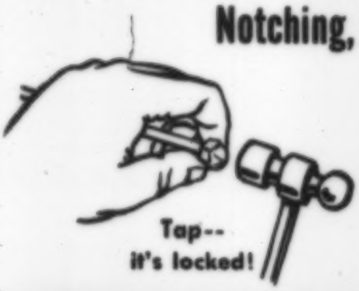

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NINE POINT GRIP
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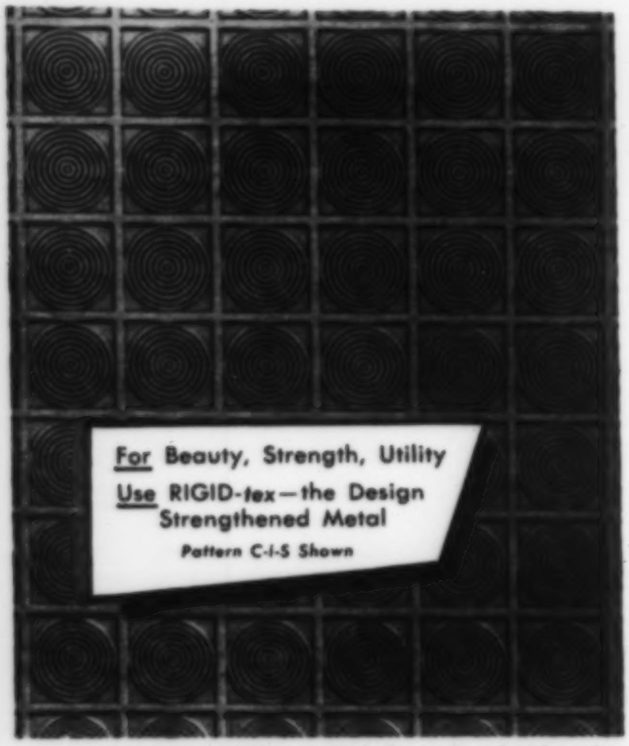

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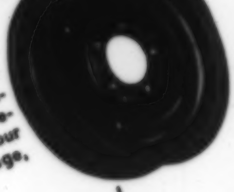

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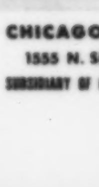

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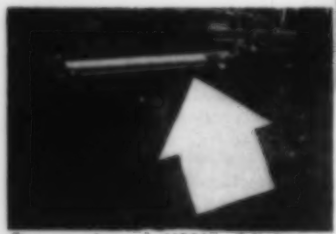
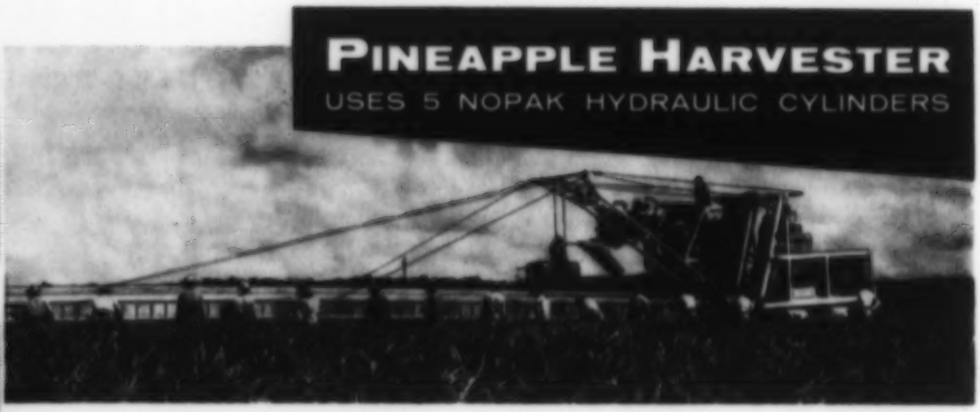
Arrows show location of 2 NOPAK Cylinders.



Close-up view of NOPAK Cylinder which rotates superstructure of harvester 210°.

NOPAK 4" x 48" cylinder positions conveyor boom to suit field conditions.



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USES 5 NOPAK HYDRAULIC CYLINDERS

Unique Machine Developed in Hawaii by Libby, McNeil & Libby Engineers*

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DESIGNED for AIR and HYDRAULIC SERVICE

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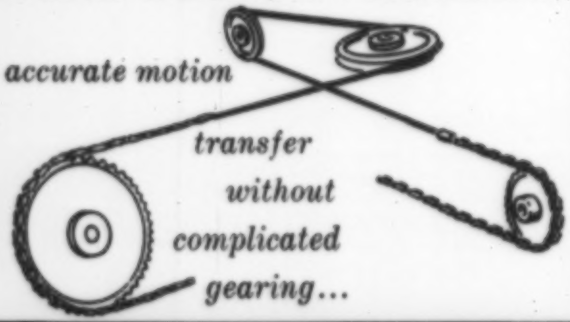

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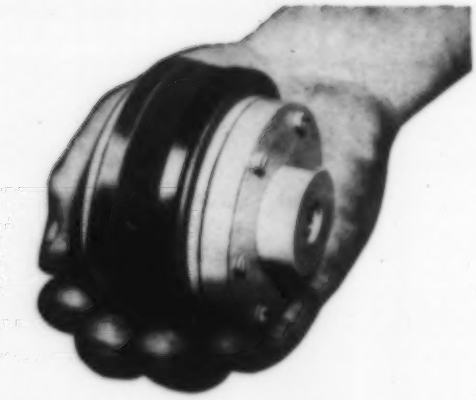

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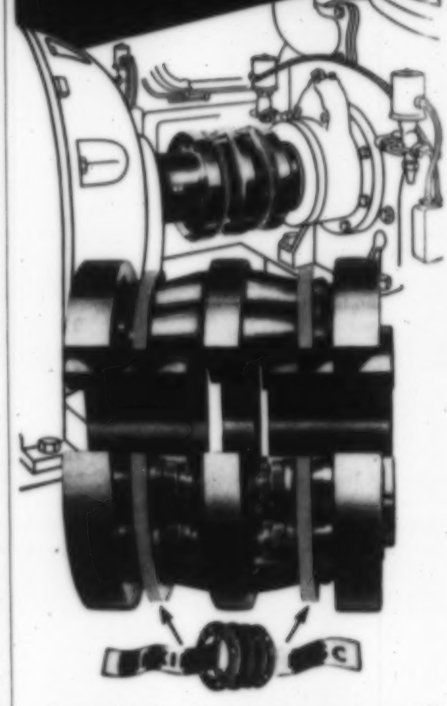

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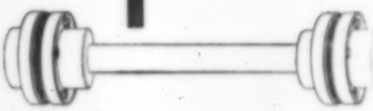

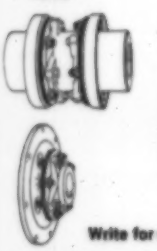

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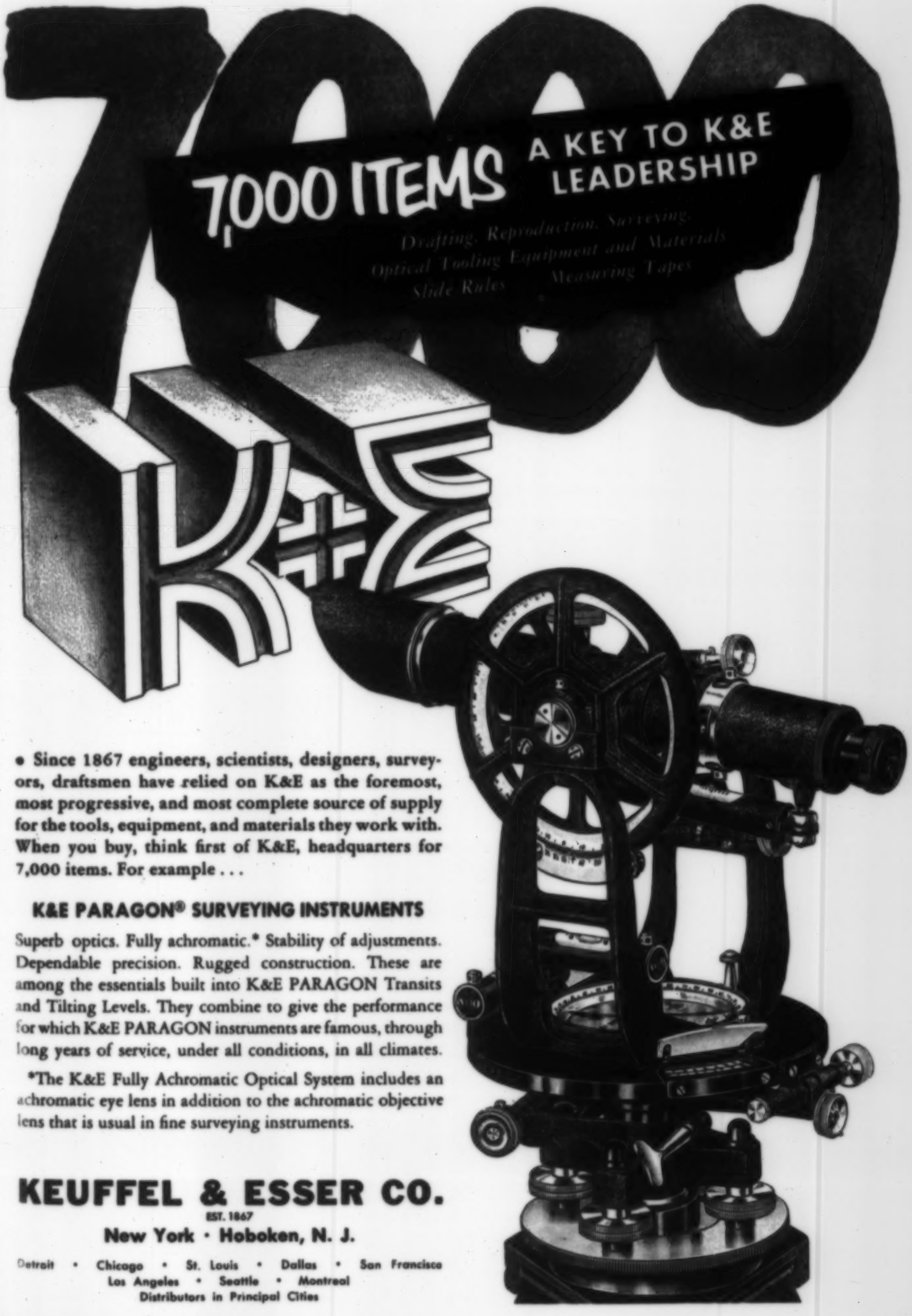
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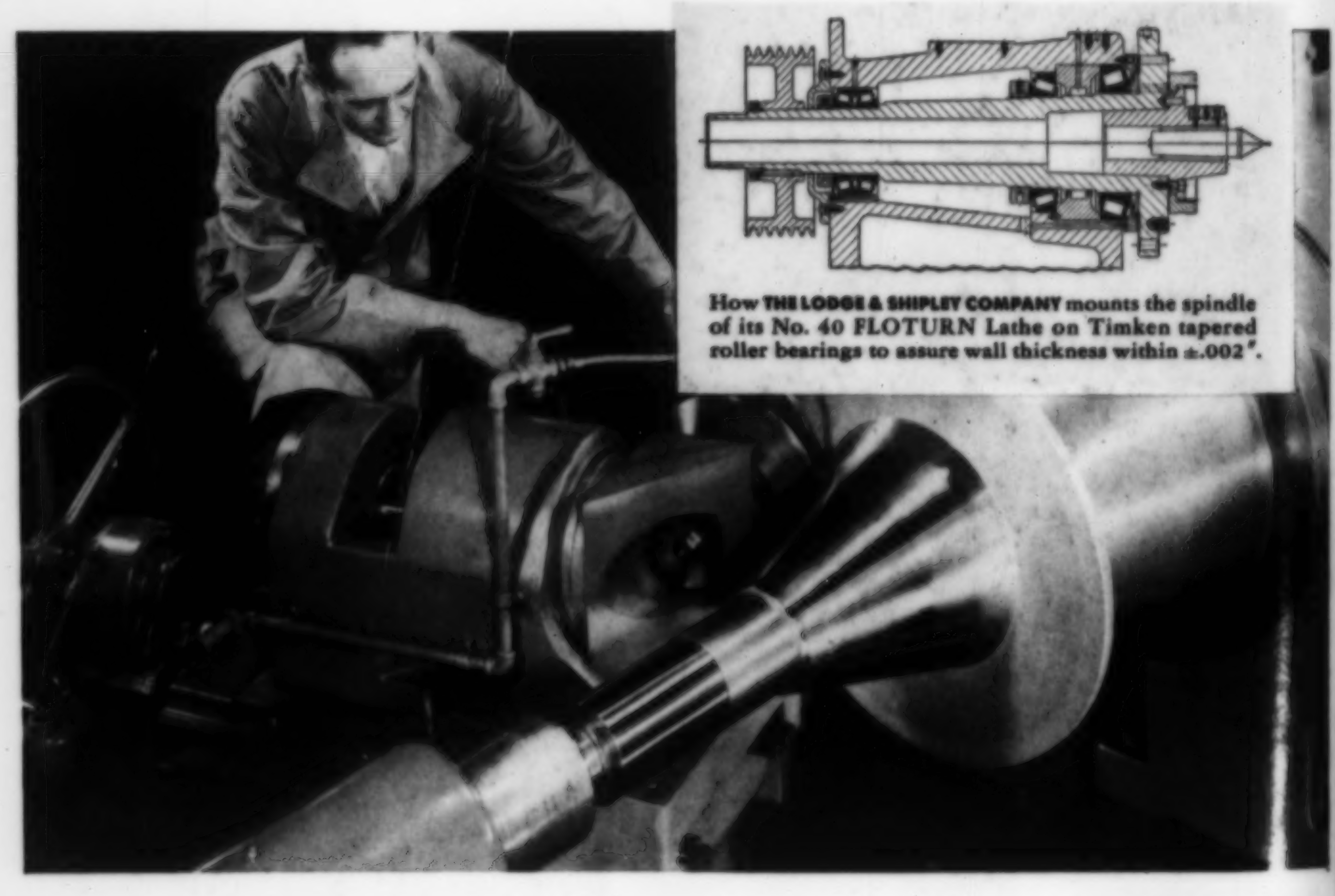

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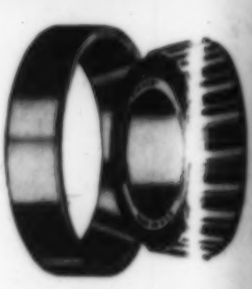

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